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MECHANICAL WORKS SPECIFICATIONS



DEPARTMENT OF PUBLIC WORKS

**STANDARD SPECIFICATION
FOR
AIR CONDITIONING AND
VENTILATION INSTALLATIONS**

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FOR
AIR CONDITIONING AND VENTILATION INSTALLATIONS
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STANDARD SPECIFICATION

FOR

AIR CONDITIONING AND VENTILATION INSTALLATIONS

SECTION 1

1.0 GENERAL REQUIREMENTS

1.1.0 NOTICE

1.1.1 This standard specification forms part of, and is to be read in conjunction with the Department's supplementary technical specifications for air conditioning and ventilation installations.

1.1.2 In so far as the conditions herein contained are at variance with anything contained in the supplementary specifications, the contract shall be in terms of the supplementary specification for each particular service.

1.1.3 Where reference is made to "Contractor" or "Sub-Contractor", it shall be read to mean the successful Tenderer appointed to execute the contract specified in the supplementary specification.

1.2.0 STANDARD MEASURES

1.2.1 The dimensions, weights, etc., shown on the drawings and mentioned in the specifications shall be taken as the Republic of South Africa's legal standard weights and measures.

1.3.0 MATERIALS AND WORKMANSHIP

1.3.1 All work is to be executed with materials of the best quality and in the most substantial manner under the inspection and to the entire satisfaction of the Department.

1.3.2 The entire installation shall be in accordance with the following:

- a) The National Building Regulations and Building Standards Act No. 103 of 1977 as amended in 1984 and all amendments thereafter.
- b) The latest revision of SABS 0400: The Applications of the National Building Regulations, as amended.
- c) SABS Code of Practice for the Wiring of Premises No. 0142 of 1981, as amended.
- d) The Machinery and Occupational Health and Safety Act No. 85 of 1993.
- e) Any other relevant by-laws of local or other authorities.

1.3.3 All apparatus, components parts, fittings and materials supplied and/or installed whether especially specified herein or not shall conform in respect of quality, manufacture, tests and performance with the requirements of the appropriate current South African (SABS) or British Standard Specifications (BS) and Addenda thereto, except where otherwise required by this specification or permitted by approval of the Department in writing. All materials and workmanship which may, in the opinion of the Department, be inferior to that specified for the work will be condemned. All condemned material and workmanship must be replaced or rectified as the case may be, to the satisfaction of the Department.

- 1.3.4 No second hand equipment of any description may be offered for supply or installation.
- 1.3.5 If so required the Department may call for samples of material and equipment for approval. Such samples shall be submitted within 14 days of the request and if judged necessary by the Department may only be returned after completion of the installation in order to ensure that the quality of the installed product is the same as that of the approved sample.
- 1.3.6 Any fitting or item of equipment not specifically mentioned but obviously necessary for the successful completion of the installation is to be included so as to form a complete working installation.

1.4.0 DRAWINGS

- 1.4.1 The tender drawings issued with the supplementary technical specification are schematic and do not necessarily purport to show the exact position, size or details of construction of equipment.
- 1.4.2 Tenderers must satisfy themselves that the equipment offered by them can be accommodated in the available space and positioned in such a way that access for maintenance, repairs or removal is not obstructed.

1.4.3 Contractor's drawings

Where indicated in the Supplementary Specification these drawings are to be prepared by the Contractor at his expense in accordance with this document and shall be on a scale of not less than 1:50.

These drawings shall at least consist of:

a) Builder's work drawings

These shall indicate all work to be done by others (bases, foundations, holes in concrete and masonry, etc.) as well as the sizes, capacities and positions of service connections (electrical, water, drainage, etc) to be provided by others, all in accordance with the supplementary specification.

b) General arrangement drawings

These shall indicate all equipment, distribution systems, testing and inspection requirements as well as instrumentation positions and access requirements.

During their preparation, the Contractor shall take cognisance of all relevant architectural, structural, electrical and other services drawings in order to properly co-ordinate his layout. These drawings can be obtained via the Department. The drawings shall be amended as required during the contract period, and up to date copies kept on site for reference purposes.

- 1.4.4 Positions and sizes of air grilles, louvred openings through reinforced concrete beams and slabs, etc., as indicated on the tender drawings shall be adhered to as far as possible. Amendments will only be considered if absolutely unavoidable.

c) Shop drawings

These shall be based on the General Arrangement drawings, and shall show in detail the construction of all the parts of the works, method of assembly where applicable, erection and construction, materials and connections, welds, gaskets, sealants, fastenings, reinforcing and all other necessary detail.

d) Electrical drawings

Electrical drawings shall comprise complete control and power wiring diagrams, as well as front and side elevations giving major dimensions of control panels as well as instrumentation and switch position layouts.

e) **As-Built drawings and wiring diagrams**

These are up-to-date approved drawings at the completion of the contract. Tenderers shall allow in their price for submitting to the Department a set of each of the up-to-date general arrangement drawings, shop drawings, as well as electrical drawings together with the O&M manuals specified herein.

1.4.4 **Submission of contractor's drawings**

Drawings shall be submitted to the Department in orderly fashion commencing within the following time limits or as determined by the main contract programme (where applicable):

Builder's work drawings	:	within 2 weeks of tender acceptance.
General layout drawings	:	within 4 weeks of tender acceptance.
Shop drawings	:	within 6 weeks of tender acceptance.
Electrical drawings	:	within 6 weeks of tender acceptance.
As-built drawings	:	at completion before first hand-over.

By submitting drawings, the Contractor 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 of his drawings with the requirements of the works and the contract documents, taking into account drawings of all other relevant disciplines.

At the time of submission the Contractor shall inform the Department in writing of any deviation in the Contractor's drawings from the requirements of the supplementary documents.

After scrutiny the Department may at its discretion and depending on the number of discrepancies, require amendment and resubmission prior to approval. Drawings shall be resubmitted until approved prior to any portion of the works related to the drawings being commenced.

Should the Contractor, during drawing amendment, alter any portion of his drawings not specifically required by the Department, he shall point this out in writing when resubmitting the drawing.

Approval of the Contractor's drawings in no way indemnifies him from being responsible for the correctness of the drawings and satisfactory operation of the installation.

1.4.6 If the Tenderer wishes to submit alternative proposals, differing from the Department's design, drawings indicating such proposals comprehensively shall be submitted with his tender.

1.5.0 **SITE CONDITIONS**

1.5.1 It is the responsibility of the Tenderer to visit the site during the tender phase and to familiarise himself with conditions related to it. If the location of the site is not indicated in the Supplementary Specification, it can be obtained from the Department. No claim for additional payment related to ignorance of site conditions will be accepted. By submitting a tender it is accepted that the Tenderer is fully aware of all site conditions as well as the access to it, and has allowed for this in his tender price.

1.6.0 **DEVIATIONS FROM TENDER DOCUMENTS**

1.6.1 No deviations or alterations from that of the specification, schedules or drawings shall be made without first obtaining the written approval of the Department.

1.7.0 PROGRAMMING OF WORK

1.7.1 The contract works shall proceed concurrently with the building construction or in accordance with an approved programme in all respects.

1.7.2 It is essential that the Contractor programmes his construction and all other work in conjunction with the Main Contractor and the main contract programme in order to avoid possible delays or clashes of trades.

1.7.3 For direct contracts the Contractor shall submit a detailed programme in the form of a bar chart based on the contract period and the various activities and components of the installation. This programme shall be submitted to the Department within two weeks of site hand-over.

1.8.0 MANUFACTURER'S RATINGS

1.8.1 All equipment such as fans, compressors, cooling towers, pumps, etc., shall be selected to be operated well within the manufacturer's ratings. Equipment offered for use beyond these limits will not be considered.

1.8.2 Tenderers must submit manufacturer's ratings of all equipment offered. Ratings shall be given in the SI system.

1.9.0 NOTICES

1.9.1 The Contractor shall supply and install all notices and warning signs that are required by the appropriate laws or regulations and by these documents.

1.10.0 GUARANTEE

1.10.1 The 12-month guarantee called for in the Supplementary Specification, shall apply to all items of plant such as chillers, etc., delivered to site and/or erected. It is the responsibility of the Contractor to negotiate with his suppliers in order to secure their equipment guarantee on this basis.

1.10.2 The date of acceptance shall be that appearing in the acceptance certificate issued by the Department and shall define the start of the guarantee period and free maintenance period (where applicable).

1.10.3 No Claims for extended guarantee or otherwise from Suppliers, Principals etc., will be considered even if equipment is required on site long before acceptance date.

1.11.0 LUBRICATION

1.11.1 All bearings must be packed with approved grease or filled with the correct oil, and all gearboxes and sumps must be filled with the lubricant specified by the manufacturer. The Contractor will be responsible for the supply of all lubricants required for the initial fill. All lubricants must be new and supplied in sealed drums or containers.

1.12.0 COMMISSIONING AND TESTING

1.12.1 Commissioning Engineers

The Tenderer shall allow in his tender price for the services of approved and expert Commissioning Engineers, as may be appropriate for the individual specialised sections of his contract, as well as a

competent Engineer in overall control of the installation. Testing and commissioning shall be carried out by these Engineers.

Should undue problems be encountered at any time, the Contractor may be requested by the Department to obtain the services of a representative of the manufacturer of specified items of equipment, at no cost to the Department.

1.12.2 Notice of Testing and Commissioning

The Department shall receive not less than two weeks advance notice of any tests to be witnessed by the Department.

1.12.3 Failure of Works, Site or Commissioning Tests

Should the Department be notified to attend official tests as laid down, and should the equipment fail the test for any reason whatsoever, such that the Department is required to re-witness the test, the time, transport and disbursement by the Department in so doing will be for the Contractor's account, which amount may be deducted, at the option of the Department, from monies due to the Contractor.

1.12.4 Quality Testing of Equipment

The Department reserves the right to arrange for testing of any piece of equipment at will, to check on compliance with the relevant specifications. Should the particular piece of equipment pass the test, the cost of such testing will be borne by the Department. However, should it fail the test, the cost of the test, rectification of the shortcomings, re-testing and repetition of the same test on the remaining like items will be for the Contractor's account.

1.12.5 Inspection during Manufacture

The Contractor will advise the Department when the items to be supplied are in the course of manufacture. The Department reserves the right to inspect any items during the course of manufacture, and witness any performance tests that may be required thereon. The Contractor shall give the Department at least two weeks advance notice of works tests.

1.12.6 Testing

The Contractor shall be responsible for carrying out all tests laid down in the specific sections elsewhere in this document, in addition to those listed hereafter and in the Supplementary Specification.

Testing and balancing shall not begin until the system has been completed and is in full working order.

The plant shall be tested and operated to meet the performance figures and duties specified.

All safety features and interlocks will be tested.

The Contractor will be responsible for all costs incurred in the testing, including the supply, calibration and use of all instruments and tools, but not the supply of water or power on site.

All instruments and test equipment used shall be provided by the Contractor, and shall be accurately calibrated and maintained in good working order. All test instruments used for tests to be witnessed by the Department's Representative shall be provided with calibration certificates, which must be available to the Department's Representative.

Specific attention is drawn to the fact that calibration certificates will be required for the following:

Watt meters, ammeters, voltmeters, frequency meters, pressure gauges, flow meters, orifices plates, temperature gauges and dynamometers.

All instruments shall be of above standard grade, and test pressure gauges shall not be less than 150mm in diameter. The maximum scale of the instrument shall not exceed 1,5 times the full test requirement.

It is essential that the Contractor inspects and tests all equipment before requesting the Department to inspect or witness acceptance tests thereon.

All acceptance tests, whether in the manufacturer's works or on site, must be carried out in the presence of the Department's Representative.

Should the Department wish to verify the calibration of any instruments, the Contractor shall make the necessary arrangements for the instrument to be re-calibrated by a recognised authority. Should the instrument prove to be correctly calibrated, the cost of the re-calibration test will be borne by the Department. Should the instrument prove to be in error, the cost of the tests will be borne by the Contractor.

Two copies of the complete test reports shall be submitted to the Department, prior to the first delivery of the project. Reports shall cover all tests carried out on individual sections, including such works tests as may have been conducted. All reports shall be neatly typed.

1.12.7 Commissioning

The Contractor shall carry out all tests and commissioning of the systems installed by him, in a co-ordinated and properly organised manner.

Air-Conditioning and Ventilation installations shall be commissioned in accordance with the following Codes or such other recognised commissioning procedure or code approved by the Department:

- a) Air Distribution Systems:
SABS 0173 : Code of Practice for the Installation, Testing and Balancing of Air Conditioning Ductwork.
- b) Refrigeration Systems:
CIBS : Commissioning Code : Series R : Refrigeration Systems.
- c) Control Systems:
CIBS : Commissioning Code : Series C : Automatic Controls.
- d) Hot Water and Steam Boilers:
CIBS : Commissioning Code : Series B : Boiler Plant.
- e) Water Distribution Systems:
CIBS : Commissioning Code : Series W : Water Distribution Systems.

Should the tests be carried out over an area outside the range of normal speech, it is required that the Contractor make available at least four battery powered, two-way radio sets, to facilitate communications.

The testing procedures shall be sufficiently comprehensive to prove the correct functioning of each and every piece of equipment, and its suitability for the application.

After all systems and equipment have been tested and commissioned to the satisfaction of the Department, a detailed demonstration of all functions of the system shall be carried out in the presence of the Department's Representative, so as to allow him to become fully acquainted with the operation of the system.

The commissioning tests shall include the tests laid down under the specific sections hereafter, and a full operational test of all pumps, compressors, fans and control gear in all modes of operation.

The Contractor shall allow for the replacement and cost of any materials and fuel used for testing purposes, as part of the contract.

The demonstration to the users shall include a repeat of the operational tests above.

The planning of this demonstration shall take place in collaboration with the Department.

A certificate of completion will not be issued until all tests have been satisfactorily completed, and the plant has operated successfully, to the complete satisfaction of the Department.

1.13.0 PERFORMANCE TOLERANCE

1.13.1 All performance figures obtained during testing and commissioning must be within -5% and +5% of the specified performance figures given in the supplementary specification. Should the plant fail to comply with these figures after it has been tested and operated for a period of seven days, then the Contractor shall have a further four weeks to meet the requirements of the specification, after which the Department shall have the right to reject the plant and recover all monies paid to the Contractor for the rejected plant.

1.14.0 TEST CERTIFICATES

1.14.1 The Contractor shall ensure that copies of all relevant test certificates, inspection reports, materials analysis certificates and similar data as may be required under various sections of this specification, or by Government Licensing and Inspection Authorities or Local Authorities, shall be provided before handing over the plant. Acceptance of the plant will be delayed if such certificates are not available. In particular, attention is drawn to pressure vessel and boiler construction and materials test certificates.

1.15.0 APPLICATION FOR INSTALLATION

1.15.1 The Contractor shall allow for the submission of the necessary forms, fees and drawings to the Inspector of Machinery or other relevant Authorities to obtain permission to install equipment where this is required. He shall also, in co-operation with the Department make any arrangements that may be required for Government Inspectors or other relevant Inspectors to carry out prescribed tests.

1.16.0 POWER, WATER AND DRAIN CONNECTIONS

1.16.1 Power, water and drain points in the plant room will be provided by and at the expense of the Department.

1.16.2 All plumbing between equipment and water and drain points shall form part of the contract.

1.16.3 The exact details of terminal points will be set out in the Supplementary Specification.

1.17.0 QUALITY OF MATERIALS

1.17.1 Only new materials of high quality shall be used throughout and shall be subject to the approval of the Department.

1.17.2 All materials, where applicable, shall conform in respect of quality, manufacture, tests and performance, with the requirements of the SABS standards or, where no such standards exist, they shall conform with the appropriate current specification of the British Standard Institution. Materials manufactured in South Africa shall be used wherever possible.

- 1.17.3 Imported materials shall comply with the requirements of the relevant SABS or British Standard Specifications, although these materials need not necessarily bear the SABS mark.
- 1.17.4 All materials shall be suitable for the particular site conditions. These conditions shall include weather conditions as well as prevailing conditions during installation and subsequent permanent use.
- 1.17.5 Should the materials or components not be suitable for use under temporary site conditions, where applicable, the Contractor shall provide at his own cost, suitable protection until these unfavourable site conditions cease to exist.

1.18.0 SERVICE ACCESS

- 1.18.1 Where equipment such as fans, dampers, etc. are installed above ceiling the Contractor shall ensure that access will be possible for maintenance purposes after installation.

1.19.0 STANDARD SPECIFICATIONS

- 1.19.1 Unless otherwise specified in the supplementary specification, the following standard specifications (including amendments) of the organisations indicated shall form part of this specification.

- a) SABS 1125-1977; Room air conditioners
- b) SABS 0140-1978; Identification colour marking
- c) SABS 0139-1981; The prevention, automatic detection and extinguishing of fire in buildings.
- d) SABS 0147-1992; Refrigerating systems including plants associated with air conditioning systems.
- e) SABS 0173-1980; The installation, testing and balancing of air-conditioning duct work.
- f) SABS 193-1972; Fire dampers.
- g) SABS 1238-1979; Air-conditioning ductwork.
- h) SABS 1424-1987; Filters for air-conditioning and general ventilation.

- 1.19.2 Tenderers shall indicate in their tender submission whether their tender and/or equipment as applicable complies with any of the above specifications or carries the SABS mark.

1.20.0 MONTREAL PROTOCOL

Tenders for equipment utilising chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs), to be supplied and installed shall be within the constraints and schedules of the Montreal Protocol and the Copenhagen Agreement and such amendments thereto as may be made by the international community.

Where tenders are submitted for equipment not complying with this Protocol it shall be clearly indicated, in writing, in the tender submission.

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STANDARD SPECIFICATION

FOR

AIR CONDITIONING AND VENTILATION INSTALLATIONS

SECTION 2

2.0 MAINTENANCE AND SERVICING

2.1.0 GENERAL

2.1.1 Unless otherwise specified in the Supplementary Specification, the Contractor shall be responsible for all maintenance and servicing of the installation for the full 12-month guarantee period. During this period, the Contractor shall make good any defect due to inferior materials or workmanship and maintain all plant and equipment in perfect operating condition.

2.1.2 The Contractor shall be entirely responsible for carrying out regular inspections at intervals not greater than 1 month, unless otherwise specified, and for full servicing of all components of the installation in accordance with the manufacturer's instructions. For this purpose, the Contractor shall prepare a detailed inspection and service report in the form a checklist and log sheet showing all functions to be carried out at each inspection and service. Copies of these service reports shall be regularly submitted to the Department after each service.

The Contractor shall also maintain a plant logbook on site in which he shall record, sign and date all work carried out at each inspection as well as log all temperatures and pressure readings etc.

2.1.3 The Contractor shall allow for all expendable materials necessary for servicing such as lubricating oils, grease, refrigerant and cleaning materials.

Replacement filters, if required, will be provided by and at the expense of the Department.

2.2.0 MAINTENANCE INSTRUCTION OF OWNER'S STAFF

2.2.1 Tenderers shall make proper allowance in their tender price for instruction of the Department's staff in the maintenance, repair and adjustment of all the equipment. Allowance must be made for the proper hands-on tuition of the owner's personnel at the appropriate time to enable them to take over operational duties.

2.3.0 SPARE PARTS AND AGENCIES

2.3.1 Where Tenderers offer plant embodying units of manufacture other than those of their principals and for which they are not accredited South African agents, and for which they do not stock spare parts, they should state in the tender the name of the accredited South African agents from whom spare parts for such units are obtainable.

2.3.2 In all cases, Tenderers should furnish an undertaking from agents to the effect that they are prepared to carry the necessary stock of spare parts for their particular units

2.3.3 Tenderers are also required to furnish the same undertakings as regards the spares for units manufactured by their own principals.

2.3.4 During adjudication of tenders, consideration may be given not only to the cost of the plant offered, but also to the cost of the spares.

2.4.0 TOOLS

2.4.1 All special tool required, i.e. tools specially designed for the particular equipment offered, must be supplied and listed in the tender offer and included in the unit price. In the case of a number of identical items of plant being supplied it will only be necessary to supply two sets of tools covering all units, and not one set for each unit.

2.4.2 It is the responsibility of the Contractor to ensure that all tools are handed over to the Department on completion of the contract, in brand new condition. No damaged tools will be accepted, and the contract will not be considered complete until such tools are satisfactorily received. Tools handed over shall be suitably mounted on a wallboard or supplied in a high quality metal box or other container as may be agreed to by the Department.

2.5.0 OPERATING, MAINTENANCE INSTRUCTIONS, WIRING AND CONTROL DIAGRAMS

2.5.1 The Contractor shall prepare and supply comprehensive manuals for the successful operation and maintenance of the installation. A draft of the manual shall be submitted to the Department after commissioning, for approval. The draft shall then be corrected, if required, and THREE sets of the manual shall be submitted before first acceptance of the plant will be considered.

2.5.2 Manuals shall be prepared in the same language as the contract document unless otherwise required by the Department. These manuals shall be bound in hard file covers with clear titles and indices and shall contain the following information as a minimum, in the sections indicated:

SECTION 1: System Description

A comprehensive description of the system, including schematic diagrams.

SECTION 2: Commissioning Data

The results of all checks and measurements as recorded during the commissioning period, shall be compiled in such a manner that every check and measurement is clearly defined.

SECTION 3: Operating Instructions

1. Plant running checklist and frequency of servicing.
2. Safety precautions to be taken.
3. Manual and automatic operation.
4. Operator's duties.
5. Lubricating oils and service instructions.
6. Pre-start checklist for each system.
7. Starting and stopping procedures.

SECTION 4: Mechanical Equipment

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1. Description of all major items of equipment with the make, model number, names, addresses and telephone numbers of the Supplier, Manufacturer or their Agents.
2. Design capacities of all equipment including selection parameters, selection curves, capacity tables, etc.
3. Manufacturer's brochures and pamphlets.
4. Schedule of spares with part numbers recommended to be held in stock by the Department.

SECTION 5: Maintenance Instructions

1. Schedule of maintenance particulars, frequency of service and replacements.
2. Troubleshooting guide.
3. Part number of all replacement items and spares.
4. Capacity curves of pumps, fans and compressors.
5. Serial number of main items of equipment.

SECTION 6: Electrical Equipment

1. Schedule of equipment indicating manufacturer, type, model number, capacity and address and telephone number of supplier.
2. Maintenance instructions.
3. Manufacturer's brochures and pamphlets.
4. Complete "as-built" circuit diagrams and diagrammatic representation of inter-connections of electrical equipment.

SECTION 7: Instrumentation and Control

1. Description of each control system.
2. Schedule of control equipment indicating make, type, model number, rating, capacity and name, address and telephone number of supplier.
3. Maintenance instructions.
4. Manufacturer's brochures and pamphlets.

SECTION 8: Drawings

1. Paper prints (reduced if so desired) of all "as-built" mechanical and electrical Contractor's drawings.
2. Wiring diagrams, framed behind glass shall be mounted adjacent to each relevant control panel.

SECTION 3

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STANDARD SPECIFICATION

FOR

AIR CONDITIONING AND VENTILATION INSTALLATIONS

SECTION 3

3.0 TECHNICAL REQUIREMENTS - GENERAL

3.1.0 ERECTION OF EQUIPMENT

3.1.1 Tenderers shall allow for a complete installation, including the provision of mobile cranes, air compressors, lifting tackle, measuring equipment, precision levels, and all other special or regular tools and equipment that may be needed to complete the entire installation in accordance with the specification, and to the satisfaction, of the Department.

3.1.2 The Contractor will be responsible for any damage caused to buildings, equipment, etc. during the course of the erection of his equipment.

3.2.0 EQUIPMENT PLINTHS

3.2.1 Plinths as specified hereunder shall not be confused with any form of inertia or anti-vibration base. Unless otherwise specified in the Supplementary Specification, equipment plinths shall form part of the air conditioning and ventilation contract.

3.2.2 Plinths shall be provided for all mechanical and electrical equipment. Plinths cast on concrete surfaces shall protrude at least 100mm above floor levels and depending on the position of the vibration mountings, shall be at least 300mm wider or longer than the inertia bases mounted on top. (Where applicable)

3.2.3 Plinths for equipment which do not need inertia bases or plinths for inertia bases with recessed vibration mountings, shall be of the same size as the equipment or bases mounted on top. Plinths shall consist of 1,6mm thick channel or angle iron formers with 10mm thick reinforcing bars located at 150mm pitch in each direction and filled with concrete. The top surface of the concrete shall be floated to an even and smooth finish to allow for not less than 25mm and not more than 50mm of suitable cement or epoxy grout under the equipment base frame. A 25mm 45° chamfer shall finish off all grout corners.

3.2.4 Plinths as specified above shall also be provided for field assembled plenum chambers and other equipment.

3.2.5 Where cooling towers are on the same floor level as condenser water pumps, the towers shall be mounted on concrete or masonry walls high enough to ensure a flooded suction at all times.

3.3.0 HOLDING DOWN BOLTS AND BOLTS FOR EQUIPMENT

3.3.1 The Contractor shall be responsible for the supply of all necessary holding down bolts for the machines supplied by him. He shall also supply all bolts necessary for assembling all the equipment supplied by him.

3.3.2 Holding down bolts shall preferably be cast into concrete bases when the bases are being cast. All bolts shall, in this instance, be provided with galvanised sheet metal sleeves approximately three times the diameter of the bolt, and projecting a minimum of four-bolt diameters below the surface of the concrete. This sleeve must be kept free of concrete until the final grouting takes place.

3.3.3 Under exceptional circumstances, the provision of suitably sized pockets for the holding down bolts will be permitted.

3.3.4 Where galvanised bolts are called for, they shall be fully galvanised all over. No re-cutting of threads will be permitted after galvanising. All nuts must run freely on the threads.

3.4.0 BEDPLATES

3.4.1 All bedplates shall be of fabricated mild steel with surfaces on which the pump, motor, gearbox, fan etc. is mounted.

3.4.2 All bedplates shall be stress relieved after welding but before machining. Each bedplate shall be provided with approximately eight horizontal jacking screws with locknuts for each unit mounted thereon to assist in aligning the pumps and motors, etc.

3.4.3 All bedplates shall be thoroughly cleaned, prepared and painted with one coat of Anodite red oxide primer to finishing coats being applied.

3.4.4 It will not be necessary to dowel equipment in place, provided the jacking screws specified above are fixed and locked.

3.5.0 COUPLING SHAFT AND VEE-BELT GUARDS

3.5.1 All couplings, vee-belts, shafts and moving parts and components shall be fitted with adequate guards which comply in all respects with the Machinery and Occupational Health and Safety Act. They shall be fabricated from sheet and flattened expanded metal, and be so arranged that the couplings or belts are completely visible through the guard.

3.5.2 All guards shall be painted as specified.

3.5.3 Guards for fluid couplings shall be so constructed as to completely enshroud the coupling, and completely contain 110% of the full volume of oil contained in the coupling. In the event of an oil discharge, no oil must be thrown about or leak onto the floor.

3.6.0 COUPLINGS

3.6.1 High speed (Above 750 r/min)

Couplings between motors and driven equipment shall be Fenaflex tyre type couplings or approved, and shall comply with the following requirements:

- i) They should be designed and selected for severe duty and 24 hours per day operation. In no case shall a "service factor" of less than 25% above that given in the Fenner Catalogue be used.
- ii) All tyre couplings must be fitted with taper lock bushes.
- iii) All couplings shall be of synthetic oil resisting rubber.

3.6.2 Low speed (Below 750 r/min)

These couplings shall in general be of a flexible type, which shall be approved by the Department.

Couplings shall in all cases be designed and selected for severe duty and 24 hours per day operation. In no cases shall a "service factor" of less than 25% above that given in the maker's catalogue be used.

Where possible, all couplings shall be fitted with taper lock bushes.

3.6.3 Hydraulic Couplings

These shall be of the Crofts, Voith or Vulcan Sinclair manufacture or as approved.

Where possible, couplings shall be fitted with taper lock brushes for both input and output shafts.

All couplings shall be adequately rated for the full power and torque rating of the motor to which they are coupled, plus 15% safety margin.

All fluid couplings must be offered with a temperature safety device, which will safely release the oil in the event of the coupling overheating.

3.7.0 MECHANICAL DRIVES

3.7.1 Vee-belt drives

Where used vee-belts shall be standard sections and lengths conforming to the latest edition of CKS 332 - 1972, "Specifications for industrial vee-belts".

Belt drives shall be designed and selected assuming direct on line starting of a squirrel cage motor and heavy duty operation for 24 hours per day. Design and selection shall be in accordance with the Fenner Power Transmission design manual or equivalent. Design shall be based on at least 2 starts per hour for all air conditioning applications. The power rating of the drive shall be based on full rating of the drive motor.

Pulleys shall be fitted with taper lock bushes. No pulley shall have a diameter smaller than that recommended by the belt manufacturer with minimum diameter being 100mm, and no non-standard pulley will be accepted.

No drive above 1kW rating shall have less than two belts.

Pulley size and centre distance shall be designed to ensure a belt contact arc over the smaller pulley of not less than 120°.

Pulleys shall be manufactured from close-grained cast iron with grooves matching belt sections and properly machined with smooth edges and wear surfaces.

Inward and outward adjustment of the drive motor and pulley combination shall be possible with proper locking mechanisms to enable correct belt tensioning and ease of replacement of belts.

All belt tensions shall be checked within 24 hours of first delivery and again one week later and adjusted as necessary.

Belt speeds exceeding 15 m/s and speed ratios greater than 7:1 are not acceptable.

3.7.2 Chain Drives

To facilitate maintenance, spares interchangeability and standardisation, chains where selected, shall be standard stock roller type precision drive chains of reputable manufacture.

The axial and angular alignment of wheels and chains shall be carefully checked to very close tolerances to ensure maximum life and trouble free operation.

The amount of adjustment possible to take up chain wear shall be not less than 2 pitches or 2 percent elongation above nominal chain length, whichever is the greater. Chains shall be lubricated in accordance with manufacturer's recommendations.

3.8.0 PACKING OF EQUIPMENT

3.8.1 All base plates and steel work shall be suitably packed with steel packs to ensure that they are true to level, line and grade. The thickness of packing shall be such as to allow for not less than 25mm, and not more than 50mm of grout under all base plates or steel work. Packings shall be of suitable size to support the base plates and one pack must be situated immediately on each side of each holding down bolt as well as in such other positions as may be directed by the Department in order to adequately support the base plates and its superimposed load.

3.8.2 All packs shall be as near as possible to the exact height in one thick piece. Thinner shims may be used for final adjustments, but large piles of thin shims will not be accepted. All packs must be of parallel shims. Taper packs or wedges will not be accepted. Packs must be bedded on a flat and smooth area on the surface of the concrete foundation. Packs resting on rough concrete will be rejected.

3.8.3 After final levelling and lining up, it is essential that all packs are tight. Loose packs will be rejected.

3.8.4 No shims will be permitted between a machine base and plate and the machine's feet except as mentioned hereinafter.

3.9.0 ALIGNMENT OF EQUIPMENT

3.9.1 Bedplates

Where equipment is delivered completely assembled on a bedplate, these items of equipment shall be removed from the bedplate prior to installation. The bedplates shall first be installed, levelled, lined up and packed to ensure that there is no twist or distortion therein. The machines shall then be installed on their bedplates and the final alignment carefully checked and adjusted until it is to the entire satisfaction of the Department.

Minor corrections to the alignment of machines may be carried out using thin shims between the machinery feet and the machined surface of the bedplate. This applies particularly to electric motors. A maximum level error of 20 seconds of arc, or as decided by the Department, will be allowed.

3.9.2 Couplings

The alignment of all couplings must be carefully checked for both the parallelism and eccentricity of their shafts. Alignment must be carried out to the maker's tolerance and to the entire satisfaction of the Department.

In any event, a misalignment of more than 0,05mm will not be permitted for either parallel or eccentric misalignment as measured at the periphery of the couplings. It is essential that a dial micrometer is used to set the final alignment, which must be witnessed by the Department.

3.9.3 Vee-belts and chain drives

The alignment of vee-belt drives and chain drives shall be carried out with a precision steel straight edge in the case of short centre drives, or by means of a nylon line in the case of long centre drives. The Contractor must ensure that all belts and chains are correctly tensioned in accordance with the maker's instructions.

3.9.4 Gearboxes

All gearboxes shall be carefully checked for level and twist. No twist in the gearbox casing will be permitted. After final levelling and bolting down, the gear teeth shall be marked with Engineer's blue, and the meshing and bearing of the teeth checked and corrected to the satisfaction of the Department.

3.10.0 ASSEMBLY OF COMPONENTS

3.10.1 It is essential that all mating components such as couplings, taper lock bushes, machined faces, etc., be thoroughly cleaned with a suitable solvent before assembly. All surfaces must be free from burrs or irregularities, which may prevent the correct mating of the surfaces.

3.10.2 A molybdenum-disulphide lubricant similar or equivalent to Mobil-grease Super shall be used on the threads of all bolts and between the mating surfaces of all parts closely fitted together, such as shafts and couplings, keys and base plates. PTFE tape shall be used in all screwed pipe connections.

3.11.0 WELDING

3.11.1 Welding shall be carried out in accordance with the current edition of SABS 044 Parts I to VII where applicable.

3.11.2 All welded filler or butt joints shall be free from porosity, cavities and entrapped slag. Joints shall be ground smooth, if required for aesthetic reasons only, without effecting weld strength.

3.11.3 The joints in the weld run, where welding has been recommended, shall be as smooth as possible and shall show no pronounced hump or crater in the weld surface.

3.11.4 The profile of the weld shall be uniform, of approximately equal leg length and free from overlap at the toe of the weld. Unless otherwise specified the surface shall be either flat or slightly convex in the case of fillet welds and with reinforcement of not more than 3mm in the case of butt welds.

The weld face shall be uniform in appearance throughout its length.

3.11.5 Filler metal electrodes shall be of an approved type for the material being used and shall be kept in a dry condition. All electrodes shall conform to SABS 455.

3.11.6 Only welders in possession of a valid approved competence certificate shall be employed.

3.11.7 All welds must show proper fusion.

3.11.8 Where welding is contemplated in pipework systems, Tenderers shall allow for the removal and testing by an approved body of 5% of the welded joints in the system. These will be removed at random as indicated by the Department and tested. Should faulty welding be discovered, all other joints shall be X-ray tested by the SABS or an approved body, all at the expense of the Contractor.

3.12.0 GALVANISING

3.12.1 Unless otherwise specified in the Supplementary Specification the following items shall always be galvanised:

Fabricated mild steel sections exposed to the weather.

Steel grilles and louvres exposed to the weather.

3.12.2 Where hot dip galvanising is called for, items to be galvanised shall be entirely pre-fabricated and then dismantled in sections for galvanising. No cutting of threads or welding will be accepted after galvanising.

3.12.3 All hot dip galvanising shall be carried out in accordance with SABS 934 and SABS 763 where applicable, including preparation for galvanising.

3.12.4 Mild steel plate and sections shall be of good commercial quality, or higher grades, best suited for galvanising. The materials shall be free from slag or coarse laminations, fine fissures and rolled-in impurities.

3.12.5 Castings shall be sound, dense and clean, and free from distortion, porosity, carbon and slag enclosures, blowholes, and other injurious conditions.

3.12.6 Welding flux shall be chipped away and all welds wire brushed before galvanising.

3.12.7 The surface to be galvanised shall be free from paint, oil, grease and similar impurities.

3.12.8 All exposed surfaces including welds shall be thoroughly sand blasted prior to galvanising.

3.12.9 The Department reserves the right to inspect all steel components before galvanising, and shall have the right to reject or ask for remedial treatment of any material which is considered to be unsuitable. This applies particularly to welds.

3.12.10 The galvanising coating shall be smooth, adherent, continuous and free from black spots or flux stains.

3.12.11 Globular extra-heavy deposits of zinc, which interfere with the intended use of the material, will not be acceptable. Excessively protuberant lumps and nodules shall be removed by hot wiping or by the skilful application of mechanical means, however there shall remain a sufficient minimum thickness of unbroken zinc coating. Flaws on small parts and working surfaces shall be repaired only by stripping and re-dipping.

3.12.12 Repairs to galvanised coatings will not be accepted. Items damaged will need to be re-galvanised.

3.12.13 Coating thickness shall be as per table 1 of SABS 763 unless otherwise specified in the supplementary specification.

3.12.14 The SABS requirement for uniformity shall apply.

3.12.15 Galvanised surfaces specified with paint finishing shall not be passivated.

3.13.0 PAINING

- 3.13.1 The entire installation, other than aluminium or stainless steel pipe cladding, shall be painted, unless otherwise specified in the Supplementary Specification.
- 3.13.2 Painted items shall include plantroom floors, equipment plinths and bases.
- 3.13.3 Before any painting is applied, the surfaces shall be prepared according to SABS 064, Code for Preparation of Steel Surfaces for Painting. All surfaces shall be moisture free, clean and properly prepared.
- 3.13.4 During painting, the Contractor shall ensure that all the necessary fire prevention and fire-fighting precautions have been taken.
- 3.13.5 Name plates, labels and notices on equipment shall not be painted.
- 3.13.6 Items which do not require painting such as diffusers and grilles, shall only be installed after the paintwork on the plant, ceiling or walls have been completed.
- 3.13.7 Painted surfaces on proprietary manufactured items shall be adequately protected. Equipment on which the paintwork has been damaged during installation shall be repainted before first delivery of the plant will be considered.
- 3.13.8 Unless otherwise specified in the Supplementary Specification the installation shall be painted in accordance with SABS colour coding where applicable. Colour code bands and arrow indicators shall be as per SABS 0140 of 1978, and the basic colour shall cover the full length and circumference of pipes and ducts.
- 3.13.9 Plastered surfaces inside plenums shall be painted with a suitable alkali resistant primer to SABS 1414-1987 followed by a universal undercoat with a final coat of high gloss enamel paint to SABS 630, Grade I. The colour of the final coat shall be white.
- 3.13.10 Lagged and plastered ductwork and plastered surfaces outside plenums shall be painted with a suitable alkali resistant primer to SABS 1414 of 1987 followed by one undercoat to SABS 681, type II and one coat high gloss enamel paint to SABS 630, Grade 1 or PVA exterior type emulsion paint to SABS 634 of 1974 as top coat.
- 3.13.11 Ferrous casings of cooling towers, evaporative condensers and sprayed coils including galvanised iron casings, sumps, fans and ductwork connected to outlets of cooling towers or evaporative condensers, shall be internally painted with two coats of epoxy-tar paint to SABS 801, type II.
- Angle iron framework shall be similarly painted with epoxy paint before side covers are fitted. All steel surfaces shall be cleaned and painted with a wash primer or zinc chromate primer (un-galvanised iron) before the epoxy paint is supplied.
- 3.13.12 Exposed and unlagged galvanised piping shall be painted with one coat wash primer (self etch primer) to SABS 723 followed by one undercoat to SABS 681, type II and one coat gloss enamel paint to SABS 630, Grade 1 as top coat.
- 3.13.13 Unlagged black piping, flat iron, angle iron, rods, etc, for supports, brackets, frames, duct stiffeners, etc, shall be painted on all sides with a zinc chromate primer to SABS 679 type 1, followed by one coat universal undercoat and one finishing coat of enamel paint to SABS 630 Grade 1.
- 3.13.14 Where specified in the supplementary specification, aluminium shall be painted with a wash primer to SABS 723 followed by a zinc chromate primer to SABS 679, type I and one coat universal undercoat to SABS 681-1972 type II and one final coat of enamel paint to SABS 630, Grade 1.
- 3.13.15 Where specified in the supplementary specification, steel surfaces shall be cleaned and then treated with the hot phosphate process to a minimum weight of 1,6 g/m² coating followed by two coats of backing enamel to SABS 783 type I.

- 3.13.16 All galvanised surfaces requiring painting other than those covered in 3.13.17 below shall be thoroughly degreased. In case a detergent is used, the surface shall be well rinsed and dried. It shall then be painted with one coat wash primer (self etch primer) to SABS 723. When dry, the surface shall be painted with one undercoat to SABS 681 type II and one coat universal undercoat and one coat high gloss enamel paint to SABS 630 Grade 1 as top coat.
- 3.13.17 All galvanised surfaces inside air handling plenums and external within 50km of the coast, or as specified in the supplementary specification, shall be cleaned with a galvanised iron cleaner until a water break free surface is achieved. After drying one primer coat of "Galvo-Grip" or approved paint shall be applied followed by one coat of universal undercoat paint. A final coat of gloss enamel to SABS 630, Grade I shall then be applied.
- 3.13.18 For air handling units the entire air-conditioning unit casings, including galvanised iron eliminators, sumps, drip pans, fans etc., shall be painted internally with two coats of epoxy-tar paint to SABS 801, type II. The white rust preventative compound on galvanised iron shall be removed as specified above before the paint is applied. Angle iron framework shall be similarly painted with epoxy paint before side covers are fitted.
- 3.13.19 Exposed piping with canvas covered insulation shall be painted two coats of bitumen aluminium paint to SABS 802 followed by the colour coding basic colour as per table 1.

3.14.0 BEARINGS

3.14.1 Anti-friction

Anti-friction bearings shall include all bearings, which provide rolling contact between one or more sets of hardened steel balls or rollers and hardened steel rings or raceways.

Anti-friction bearings shall be of approved manufacture and available throughout South Africa.

To facilitate maintenance, spares interchangeability and standardisation, anti-friction bearings of standard design and manufacture shall be employed. All anti-friction bearings shall be provided with greasing facilities in accordance with manufacturer's requirements.

3.14.2 Bushed Bearings

Only where specifically stated in the Supplementary Specification and in the case of low velocities and light loads in moisture free conditions will bushed bearings be accepted. All bushed bearings shall be made of an approved bearing metal composition, which has good anti-friction qualities and is capable of withstanding severe usage in the specific application.

All bushed bearings shall be provided with lubrication facilities to ensure adequate lubrication and shall be properly grooved to distribute the lubricant uniformly over the bearing surfaces. Grooves shall not be cut into the journal, but always into the surrounding bush. The edges of all chambers and grooves shall be rounded to avoid sharp corners and to facilitate the introduction of the oil or grease between the journal and the bearing metal.

3.14.3.1 Self-lubricating or oilless bearings

Self-lubricating or oilless bearings shall only be used on application of light and low velocities in moisture free and low humidity conditions and where access to bearings is difficult and likely to be neglected during servicing.

The type of bearing metal composition used shall have frictional and wear resistant properties akin to those of grease lubricated bushed bearings.

3.15.0 NOISE AND VIBRATION CONTROL

3.15.1 General Unless otherwise specified in the Supplementary Specification the design, manufacture and installation of all the mechanical and electrical equipment shall be such as to ensure compliance with the relevant sections of SABS 0103 of 1983 "The Measurement and Rating of Environmental Noise with Respect to Annoyance and Speech Communications", as amended.

Any installation where the measured residual sound level exceeds the maximum desired residual sound level as per SABS 0103 shall be rectified to comply with SABS 0103 at the Contractor's own expense.

In all plantroom applications where airborne noise cannot be limited or comply with the set standards, provision shall be made for acoustical treatment of the equipment involved or, alternatively, total enclosure thereof with acoustical panelling to comply with requirements laid down in this specification.

Such provisions shall be included in the tender price and no claims for payment to comply with this requirement will be entertained.

3.15.2 Vibration Isolation

Proper provisions shall be made in the foundations and mountings of all equipment capable of transmitting vibration forces to its environment, whether local or remote, (As is the case with pipes) for vibration isolation.

The following table of recommended isolation efficiencies for critical areas applicable to heavy mass concrete floor slabs serves as a guide only:

CRITICAL AREAS	TRANSMISSIBILITY	ISOLATION EFFICIENCY
1. Centrifugal compressors and chillers	0,5%	99,5%
2. a) Centrifugal fans larger than 15kW b) Reciprocating compressors larger than 40kW c) Pumps larger than 4kW	1%	99%
3. a) Axial flow fans larger than 20kW b) Centrifugal fans up to 15k W c) Reciprocating compressors up to 40kW d) Pumps up to 4kW e) Unit air conditioners f) Fan coil units	3%	97%
4. a) Axial flow fans up to 20kW b) Air handling units	4%	96%
5. a) Pipes b) Electrical connections, conduit cabling etc.	8%	92%
6. Boilers, steam and central heating, larger than 20kW		4 to 7 Hz

The following table of recommended isolation efficiencies for general areas applicable to heavy mass concrete floor slabs serves as a guide only:

CRITICAL AREAS	TRANSMISSIBILITY	ISOLATION EFFICIENCY
1. Centrifugal compressors and chillers	5%	95%
2. a) Centrifugal fans larger than 15kW b) Reciprocating compressors larger than 40kW c) Pumps larger than 4kW	8%	92%
3. a) Axial flow fans larger than 20kW b) Centrifugal fans up to 15k W c) Reciprocating compressors up to 40kW d) Pumps up to 4kW e) Unit air conditioners f) Fan coil units	10%	90%
4. a) Axial flow fans up to 20kW b) Air handling units	15%	85%
5. a) Pipes b) Electrical connections, conduit cabling etc.	20%	80%
6. Boilers, steam and central heating, larger than 20kW		8 to 15 Hz

Selection of vibration isolation equipment and in particular, mountings for equipment and machines, shall be done with due regard to the forcing frequency of the driven machinery and the mounted natural resonant frequency of the machine.

In the case of installation of equipment on upper floors, suspended floors, roofs etc. it is of prime importance that floor stiffness, floor, deflection and natural frequency of the floor be taken in to consideration to ensure that resonant conditions cannot occur.

Driven machinery and isolator deflections shall be carefully selected in these applications.

Equipment selection schedules shall be submitted to the Department for approval and shall contain full details regarding the forcing frequency, the natural mounting frequency, the static deflection and all other relevant information to evaluate vibration isolation equipment.

Should added mass inertia blocks be required to comply with these vibration isolation requirements, proper provision shall be made at tender stage for the provision of such.

3.15.3 Damping

Where static deflections in excess of 8mm are indicated, steel springs shall be employed incorporating acoustic sound pads in series with the spring.

The horizontal stiffness of the springs shall not exceed that in the vertical, in particular for systems mounted at vertical frequencies below 5Hz.

Low frequency mounts shall incorporate rubber snubbers to accommodate extreme horizontal or vertical motions such as can occur near resonance during start up.

The snubbers shall however not be relied upon to provide the necessary horizontal stability of the machine in normal operational conditions.

Spring layouts and inertia blocks shall be employed to avoid this situation.

For static deflections below 8mm, rubber in shear mounts may be used provided the frequency is above 6Hz.

For small static deflections less than 4mm and particularly for high-speed machines and general acoustic isolation, ribbed rubber neoprene composite pads may be employed subject to the specified requirements.

No equipment shall be installed in critical areas without correct and approved vibration isolation.

Sufficient stability and damping shall be incorporated in the mountings to minimise the movement of the machine during start up or changes in the operating conditions.

The selection of mounts shall take proper cognisance of unequal distribution of the mounting weight of equipment and rotational and/or pressure forces acting thereon.

3.15.4 Refrigeration Chillers

3.15.4.1 Indoor Units

Indoor units shall be carefully selected with due regard to vibration transmission to pipework and the surrounding structure and airborne noise transmitted to the plantroom. Where the airborne noise inside the plantroom exceeds the limits laid down, provisions shall be made in the tender for the total enclosure of the chiller with acoustic panelling to ensure acceptable noise levels.

Spring mounting of compressors only on the basic chiller framework as supplied ex factory will not be sufficient. In addition, (unless otherwise specified in the supplementary specification) the complete chiller unit shall be installed on spring mountings of the correct deflection characteristic.

For critical areas, the standard spring mounting of the chillers will not be sufficient. In addition, inertia mass will be required with the chiller unit as a whole mounted on correctly selected spring mounts. Deflection in excess of 40mm can be expected.

Indoor air cooled chillers shall in all cases be fitted with centrifugal fans for the condenser section. The complete unit with fan/s, ducting grilles etc. shall comply with the requirements laid down in this specification.

3.15.4.2 Outdoor Chillers

Where outdoor type air-cooled chillers are specified in critical areas, in addition to the laid down requirements, condenser-cooling fans shall be of the centrifugal type and provided with attenuation.

Centrifugal fans and attenuation shall be provided where necessary to meet the laid down noise criteria for other areas.

Acoustic panelling to the chiller housing shall similarly be provided for equipment where necessary to comply with the laid down criteria.

SABS 0103 has reference.

3.15.5 Cooling Towers

3.15.5.1 Indoor Applications

Anti-vibration requirements and noise transmission to surrounding areas shall comply with requirements as laid down (unless otherwise specified in the supplementary specification). No

cooling tower shall be installed indoors unless it is mounted on anti-vibration spring mountings and should it be necessary, the required inertia mass.

3.15.5.2 Outdoor Applications

Cooling towers installed outdoors shall similarly comply with the laid down noise criteria for this application, particular care being paid to the selection of the fans and where applicable, the pumps for critical areas.

3.15.5.3 Cooling Tower Fans

Centrifugal fans shall generally be required for indoor application of cooling towers and for outdoor applications in critical areas.

In critical areas it will possibly be required that proper attenuation be applied to air inlets and air discharge of cooling towers and, where so specified in the supplementary specification, the total cooling tower shall be installed inside acoustic panelling to prevent noise breakout.

Alternatively ejector type cooling towers may be offered, subject to the requirements of this specification.

3.15.6 Pumps

All pumps with their motors shall be mounted on a baseframe, which shall be installed on concrete plinths.

In addition it is required that pumps installed indoors and in critical areas shall be installed on anti-vibration mountings with inertia mass bases with mountings selected for correct static deflection.

Bases for pumps in non-critical areas shall be installed on rubber in sheer mounts as a minimum, depending on the pump selection and locality of the pump.

Where required in the supplementary specification, pumps shall be totally enclosed in acoustic panelling to reduce noise breakout to the immediate vicinity and surrounding areas.

3.15.7 Fans

3.15.7.1 Centrifugal Fans

No centrifugal fan shall be selected in a class range other than Class 1 or 2 and the rotating speed of the fan at duty point shall not exceed 1 440 r/min.

Centrifugal fans in critical areas and fans above 7,5kW shall in all cases be mounted together with the drive motor on anti-vibration mountings together with the correct inertia mass.

3.15.7.2 Propeller Fans

Propeller fans shall comply with the criteria already laid down and shall be carefully selected for the highest possible efficiency with due regard for the noise criteria.

Propeller fans in excess of 0,5kW and of rotational speed higher than 800 r/min shall, in addition to the requirements already laid down, be mounted on correctly selected and installed anti-vibration mountings to reduce possible vibration transmission to surrounding structures.

3.15.7.3 Axial Flow Fans

Axial flow fans shall be selected for the highest possible efficiency and comply with the noise criteria specified. In critical areas no fan shall be installed without attenuators on inlet and outlet sides.

In addition it will be required that the fan as a whole be mounted on anti-vibration mountings and where specified in the supplementary specification, it may be required for the fan to be enclosed in acoustic panelling.

No axial flow fan may be installed without anti-vibration mountings to match the fan characteristics and in critical areas it may be required for the axial fan to be provided with inertia mass to match.

Fan rotational speeds specified in the supplementary specification shall not be exceeded.

3.15.7.4 General

No fan may be directly connected to ducting either on the inlet or outlet sides, approved flexible connections shall be provided between the fan and the ducting distributing the air.

Where fan noise characteristics cannot meet the requirements of this specification such fans shall be replaced or other approved steps taken by the contractor at his own expense until the installation meets the requirements.

3.15.8 Air Handling Units

3.15.8.1 General Application

Air handling units shall comply with the requirements already laid down for noise vibration and noise criteria.

In the case of built-up air handling units, the fan and motor unit shall be mounted on anti-vibration mountings and in the case of critical areas, be provided with additional inertia mass to comply.

In the case of packaged factory-built units, it shall be necessary to mount the fan and motor unit on anti-vibration mountings internally to the unit and in addition, it will be required for the air handling unit as a whole to be mounted on anti-vibration mountings of the correct static deflection characteristic.

In critical areas, it will be necessary to provide additional inertia mass for the fan and motor combination in addition to the above.

Where necessary to comply with the noise criteria laid down, air handling units shall be provided with internal acoustic panelling to match the fan characteristic and to comply with the noise criteria laid down.

3.15.8.2 Hospital Applications

In hospital applications, the noise criteria already laid down for critical areas and as per SABS 0103 shall apply and the general requirements set out above.

However, no internal insulation or acoustic panelling will be permitted and all noise reduction required shall be done external to the air path.

3.15.9 Piping

3.15.9.1 General

Under no circumstances may any piping be directly connected to noise generating equipment such as pumps, chillers, cooling towers etc.

Connections to such equipment shall be made with correctly selected flexible rubber type connectors of the spherical type.

In critical areas double spherical rubber type isolators immediately adjacent to the noise generating machine will be required.

3.15.9.2 Pipe Penetrations Through Walls

Under no circumstances will pipe penetrations through walls be permitted where the pipe comes in direct contact with the surrounding wall or structure.

At such penetrations it is required that a sleeve of 25mm thick soft neoprene, or other approved material, be provided around the piping at the penetration and, where plastering is applied, plastering shall be cut back to the outer edge of this sleeve.

Rubber links similar to the LINK-SEAL bolted type are preferred.

3.15.9.3 Pipe Supports

In all critical applications and within the first ten metres of all equipment, it is required that pipe supports shall be of the flexible type, correctly selected for the application and with the correct static deflection.

Depending on the application spring mounting will in all probability be required.

Any other areas and applications at risk of noise or vibration transmission to the surrounding structure similarly require pipe mountings isolated from the structure.

Pipe supports fixed to sensitive building elements will not be permitted.

3.15.9.4 Refrigerant Piping

Refrigerant piping in critical applications shall similarly be supported on anti-vibration mountings and in addition, delivery and suction piping at compressors and air handling units shall be provided with at least two braided flexible connections installed at 90° to each other and in close proximity of each other.

3.15.10 Sound Attenuators

Where required, in order to comply with the noise and vibration criteria already laid down, or where specified in the supplementary specification, sound attenuators shall be provided for ventilation, air conditioning and all other plant (Duct mounted and/or as applicable).

Primary sound attenuators shall be installed near or in the plantroom.

The attenuators selected shall match the specific fan or plant characteristics to ensure the correct insertion loss to meet the sound criteria laid down.

Unless otherwise specified, sound attenuators shall be installed with flexible connections at the inlet and outlet connections.

The sound attenuators shall in addition be selected to produce the minimum pressure loss across the attenuator coupled to the least re-generated noise level produced by the flow through the attenuator.

Unless otherwise specified, air path sound attenuators shall be manufactured from galvanised sheet steel with the sound absorption material moisture repellent and erosion resistant up to 20 m/s air speed, and preferably flange connected.

Wherever possible attenuators shall be proprietary type supplied by the same manufacturer as the plant manufacturer to ensure complete compatibility.

Where not clearly indicated on the drawings, attenuators shall in all cases be provided at points where supply and return air ducting leaves the plantroom and shall be installed to prevent noise breakout from the plantroom via the ductwork.

Where specified in the supplementary specification and indicated on the drawings, additional cross talk attenuators shall be installed in the air conditioning or ventilation ductwork.

The internal free area of sound absorbers shall be not less than the cross sectional area of the connecting duct as indicated on the drawings.

Field fabricated type sound absorbers shall be made as follows:-

All sides of rectangular ducting shall be double walled with the inner walls perforated with 10mm holes at 25mm centres. The space between the two sidewalls shall be divided into 3 unequal sections by means of 25mm thick cement fibre panel strips and filled with glass wool. The lining thickness shall be at least 80mm.

Circular ducts shall be lined as specified above except that the lining thickness shall not be less than 100mm.

3.15.11 Air-Borne Noise

Selection and installation of all items such as grilles, diffusers, dampers, jet outlets, nozzle outlets, transformation pieces, takeoffs, etc. shall be carried out in such a manner to ensure compliance with the noise criteria laid down in this specification. Items shall be carefully selected to reduce generated noise levels to accepted levels and with minimum air pressure loss.

Items such as dampers, volume control items etc, shall be carefully selected with due consideration for noise regeneration in all possible positions of such dampers or items to ensure compliance in all positions.

All duct penetrations through walls and structures shall be provided with a 25mm thick soft neoprene or similar approved material sleeve surround to ensure that no direct contact between the duct and wall occurs. For plastered walls the plastering shall be cut back to the outer edge of this sleeve.

3.15.12 Room Units

Where room units such as air conditioners, fan coil units, VAV outlets or induction units are used, it is essential that the acoustical characteristics of such units are considered during selection and that they are installed to ensure compliance with the noise criteria laid down.

The sound pressure level from these machines shall be within the set criteria throughout the frequency range.

3.15.13 Noise to the Exterior

Where specified in the supplementary specification, additional measures shall be taken to prevent or reduce noise breakout to the exterior from the plantrooms.

In critical areas it is essential that all possible steps be taken and be allowed for at tender stage to ensure compliance with the requirements laid down.

No allowance shall be made for screening or attenuation with distance in calculating requirements.

3.15.14 Electrical Connections

In critical areas no conduit or armoured cabling may be connected directly to equipment. Flexible connections shall be used in these applications.

In other applications cabling shall be connected to equipment with long radius bends. No sharp corners or bends in cabling may be used.

Electrical connections shall not impede anti-vibration mountings and shall not convey vibrations or sound to the structure or building elements.

In critical areas cabling, trunking etc. shall be supported in a manner to ensure no vibrations are conveyed to the structure. Supporting from sensitive elements of the structure will not be permitted.

Where floating floors, acoustical separating elements etc. are used in a structure, flexible connections, conduit etc. shall be used at all crossover points.

3.15.15 Testing

When called upon to do so by the Department, the Contractor shall provide at his expense, all necessary equipment required to ascertain compliance with noise and vibration elimination in the installation.

The instruments provided shall be calibrated by an approved Authority and shall be capable of measuring sound and vibration levels integrated over a period of time.

The instrument to measure sound pressure levels must be capable of reading sound levels in dBA as well as the sound level at the international octave band centre frequencies of 31,5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz as a minimum.

The instrument to measure vibration levels shall be calibrated in nano m/s over the integration period.

In the event of such tests indicating insufficient provision for eliminating airborne noise and vibration transmission, the Contractor shall at his expense rectify the installation as necessary and the tests shall again be executed until satisfactory results are obtained.

Final approval of the noise and vibration levels shall be at the sole discretion of the Department.

3.16.0 ELECTRICAL EQUIPMENT AND INSTALLATION

3.16.1 Unless otherwise stated in the Supplementary Specification tenderers must allow in their price for the complete electrical installation and wiring.

3.16.2 All electrical equipment and wiring shall be in accordance with the current issue of the Department's Standard Specification for Electrical Equipment and Installation for Mechanical Services. Copies can be obtained from the Department, Private Bag X65, PRETORIA, 0001.

3.16.3 Power terminal points will be as specified in the Supplementary Specification.

3.16.4 Ammeters and pilot lights shall be provided for electric heaters, one of each for each step of heating.

3.16.5 All compressor motors over 5kW shall be provided with an approved electronic type motor protection unit in addition to the protection called for in the Standard Specification for Electrical Equipment and Installation for Mechanical Services.

- 3.16.6 Clause 1.2.1 (a) of the Standard Electrical Specification shall read "The South African Bureau of Standards Code of Practice for the Wiring of Premises as amended".
- 3.16.7 In conventional field assembled plants lighting wired from the air conditioning control panel shall be provided for the filter chamber, coil chamber and fan chamber and shall comprise of bulkhead fittings permanently fixed to the walls or ceiling and earthed directly to the main earthing bar of the switchboard by means of a 4mm² bare copper earth continuity conductor, in addition to being earthed by means of the continuity of the conduit as specified in the Standard Electrical Specification.
- 3.16.8 The fault level of the air conditioning distribution board shall be as specified in the Supplementary Specification.
- 3.16.9 In the case of small wiring direct from busbars, e.g. voltmeter supply, suitable protection fuses shall be mounted directly onto the busbars.
- 3.16.10 The possibility of inadvertent contact with live terminals shall be avoided at all cost. All apparatus and wiring behind readily accessible hinged doors or panels shall be protected against finger contact by means of insulating panels (Perspex or similar approved material) or other approved method. Busbar mounted voltmeter fuses shall be mounted on insulated back plates to afford complete safety from hand contact with busbars or other conductors in the immediate vicinity.
- 3.17.0 SELECTION OF EQUIPMENT
- 3.17.1 All equipment shall be selected with due regard to the installation site conditions, particularly with respect to;
- ? altitude
 - ? ambient temperatures
 - ? atmospheric conditions
- 3.17.2 Equipment shall at all times be selected to operate within the limits recommended by the particular manufacturer.
- 3.17.3 Where equipment will be required to operate at conditions deviating from the manufacturer's standard selection tables, re-rating shall be done strictly in accordance with the manufacturer's methods.

SECTION 4

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STANDARD SPECIFICATION

FOR

AIR CONDITIONING AND VENTILATION INSTALLATIONS

SECTION 4

4.0 TECHNICAL REQUIREMENTS - EQUIPMENT AND MATERIALS

4.1.0 ROOM TYPE AIR CONDITIONERS - AIR COOLED

4.1.1 General

4.1.1.1 Room type air conditioners shall be completely self-contained units of the direct expansion unitary or split type design, air-cooled.

4.1.1.2 The air conditioners shall generally be in accordance with SABS 1125-1977 with sound levels not exceeding the values specified in the Supplementary Specification and/or this Standard Specification as applicable.

4.1.1.3 Room air side shall be equipped with a suitable and easily accessible filter, two speed fan, adjustable directional air discharge grille, adjustable outside air intake damper, control thermostat, electric heating elements (if not specified as reverse cycle heating) (where applicable), drain pan and drain piping, cooling coil, controls and control panel and complete wiring, including interlocking with outdoor unit.

4.1.1.4 The outdoor unit shall contain the matching compressor unit, air-cooled condenser, condenser fan within a waterproof painted and corrosion protected casing.

4.1.1.5 The indoor/outdoor units shall be interconnected with refrigerant piping (separately insulated suction and delivery piping for reverse cycle units), electric wiring and interlocking control cabling.

Where visible and/or exposed to the weather or possible mechanical damage refrigerant piping and cabling shall be run inside galvanised sheet steel trunking, neatly erected and painted as specified.

4.1.1.6 Where applicable provision shall be made in the unit design to re-evaporate condensate from the condenser.

Provision shall however be made in all cases for the drainage of excessive condensate to the nearest building drain by means of copper or uPVC tubing (refer to Supplementary Specification) not less than 18mm diameter.

For reverse cycle heating units, including split type units, a proper dripan with drainage piping as above shall be provided for the outdoor units where dripping can create unacceptable conditions.

Where drainage piping is required to be installed flush mounted, positioning and chasing shall be done in good time to meet construction programmes.

Drainage to points other than a proper building drain shall comply with SABS 0400.

4.1.1.7 All panels shall be neat fitting with hardwearing exposed surfaces of baked enamel or equal finish of approved colour.

4.1.1.8 Electrical interlocking shall be provided to ensure that;

- a) compressor cannot run without both indoor and outdoor fans running,
- b) electric heating elements can only be switched on if the indoor fan is running,
- c) it shall not be possible to switch cooling and heating on simultaneously.

4.1.1.9 Unless otherwise specified in the Supplementary Specification room type air conditioners in the cooling mode shall be rated at 35°C ambient dry bulb air temperature on to the condenser, 27°C dry bulb and 19°C wet bulb air entering conditions to evaporator, all at sea level with the cooling capacities specified at these conditions. For reverse cycle heating the rating shall be based on 7°C ambient dry bulb and 6°C wet bulb air on to the outdoor coil with 21°C dry bulb air on to the indoor coil.

4.1.1.10 Unless otherwise detailed on the drawings or in the Supplementary Specification units installed through a wall shall be installed with a subframe built in to the wall (hardwood or steel) and neat finishing architraves inside and outside. The external architrave shall be of aluminium angle and shall be mitred at corners and shall cover the subframe and opening completely. The architrave and subframe surround shall be sealed with clear silicone sealant.

4.1.2 Coastal Applications

For coastal applications special considerations and requirements are called for namely;

4.1.2.1 All steel parts exposed to the atmosphere or to ambient air (including outdoor unit air path) shall be either hot-dip galvanised or electroplated to SABS 728 of 1970 before painting.

4.1.2.2 Outdoor unit coil shall be constructed of copper to copper tubing and fins.

4.1.2.3 Electric terminals and connections shall be corrosion protected with non-hardening mastic or equal coating.

4.1.2.4 The complete compressor unit shall be sprayed with a continuous skin of PA 10 plastic film, or equal.

4.1.2.5 Fan motors, fan scroll and internal fan wheels shall similarly be sprayed with a PA 10 plastic film or equal.

4.1.3 Window Type Units

4.1.3.1 Window type room air conditioners shall be suitable for mounting in window frames or wall openings and shall be completely self-contained.

4.1.3.2 The units shall be made up in two parts namely the chassis or cabinet and the main body. The cabinet shall be mounted in the window frame or wall. The main body shall slide in/out on self-locating guides and guide strips to facilitate maintenance.

4.1.3.3 Where a unit is installed beyond normal reach the controls shall be installed remote at eye level.

Unless otherwise specified in the Supplementary Specification all wiring between the unit and the remote control shall be installed in flush conduit and draw-boxes.

4.1.4 Console Type Units

4.1.4.1 Console units shall be completely self-contained and shall be mounted above skirting height for cleaning purposes.

4.1.4.2 Units with a two-part construction allowing the cabinet to be built in to the wall with the main body to slide in or out is preferred.

4.1.4.3 Matching weather tight air intake and exhaust louvred panels of anodised aluminium with horizontal blades shall be provided and installed with each unit.

Depending on size, detail and wall thickness the louvre shall form part of the cabinet or shall be fixed to the subframe.

4.1.4.4 Units shall be supplied with the manufacturer's standard 2 kW electric heating element thermostatically controlled.

Reverse cycle units shall only be supplied if called for in the Supplementary Specification.

4.1.5 Split Type Units

4.1.5.1 Split type units shall consist of a direct expansion indoor fan coil unit and a separate (remote) externally located air-cooled condensing unit.

4.1.5.2 The indoor fan coil unit shall be floor-mounted, wall mounted, under-ceiling mounted, ceiling cassette mounted or above ceiling ducted type as specified.

4.1.5.3 Above ceiling units shall be properly insulated, particularly where exposed to high roof or lighting heat loads.

4.1.5.4 Remote controls shall be wired in conduit and mounted at eye level in the positions indicated on the drawings.

4.1.5.5 All conduit and draw boxes shall be installed flush in the walls or partitions.

Surface mounted wiring in trunking or the like will only be accepted if specified as such.

No joints will be allowed in the control wiring.

4.1.5.6 Suction lines shall be insulated as specified. Suction and delivering lines may not be insulated grouped together as for a single line. Vapour barrier integrity will be critical to prevent dripping.

4.1.5.7 Gas piping (insulated as specified) and wiring shall be installed in galvanised steel trunking throughout for protection, painted as specified where exposed or visible.

4.1.5.8 Outdoor units shall be installed on raised plinths or where wall mounted on unistrut or approved galvanised steel brackets, properly braced and fixed.

4.1.5.9 Refrigerant piping shall be sized and fitted with the necessary oil traps strictly in accordance with the manufacturer's requirements.

4.2.0 FANS

4.2.1 General

4.2.1.1 Fan duties are specified in the Supplementary Specification.

Where no pressure requirements are indicated Tenderers shall estimate the fan static pressure requirements for the system layout and equipment as offered by them and tender accordingly.

4.2.1.2 Fans shall be selected to operate at or as near to maximum efficiency as possible.

4.2.1.3 Flexible connections shall be fitted between fan inlet/discharge and ducting or equipment as appropriate. Flanges are required with flexible connections.

4.2.1.4 Fans shall be fitted with manufacturer's nameplates permanently fixed to the casing in a prominent position clearly indicating manufacturer, model number, maximum operating speed, maximum power absorbed, size and serial number for larger fans.

4.2.1.5 Air in/outlets not connected to ducting or equipment shall be properly protected with removable screens as per SABS 0400.

4.2.1.6 Indicating arrows for both direction of rotation and direction of airflow shall be provided on fan casings.

4.2.1.7 Fans for special applications such as corrosive gas, explosive atmospheres etc. shall be specified as such in the Supplementary Specification.

4.2.1.8 Fans for proprietary and package units although not specifically covered in this specification shall however comply with the general requirements of this specification.

4.2.2 Centrifugal Fans

4.2.2.1 Centrifugal fans shall be of the forward or backward curved, multi-vane type with single or double inlet and arrangement as specified in the Supplementary Specification.

4.2.2.2 Fan performance shall be based on tests carried out in accordance with BS 848 : Part 1 or Part 3 (as applicable) and as amended.

4.2.2.3 The fan casing shall be of the volute type manufactured from sheet steel with lock forming or continuously welded seams, suitably reinforced and adequately supported by means of a steel superstructure.

4.2.2.4 Fan wheel and shaft assembly shall be statically and dynamically balanced to ISO 1940 - 1973 within grade G6,3.

4.2.2.5 Fan drives shall be by means of standard V-belt and grooved pulley configuration. Drive motors mounted on the fan casings are not acceptable.

4.2.2.6 Larger fans shall be manufactured with split casings in sections to permit installation through available openings in new and existing buildings.

4.2.2.7 Shaft bearings shall be grease lubricated, self-aligning ball or roller bearings in accordance with the fan manufacturer's standard practice. For bearings located in the air stream, precautions shall be taken to prevent loss of lubricant.

4.2.2.8 Shafts shall be fully machined steel shafting conforming to BS 970 grade 070M20.

4.2.2.9 A drain socket with plug shall be provided at the lowest point in the fan casing (except if discharge is at lowest point).

- 4.2.2.10 Fans used in variable volume applications shall have stable characteristics throughout the operating range.
- 4.2.2.11 All fans shall be tested in the factory and checked for vibration to ISO 2372, smooth running, mechanical interference. Bearings shall be checked using a shock impulse meter.
- All measurements and observations made during this test run shall be recorded and made available to the Department on request.
- 4.2.2.12 Fan motors in the air stream in draw-through applications with spray coolers or sprayed coils shall be TEFC and protected to IP44 or better.
- 4.2.2.13 Shafts for variable inlet vane control shall be supported by pre-lubricated sealed bearings.
- Both sets of variable inlet vanes on double inlet fans shall be controlled simultaneously and equally.
- Variable inlet vanes shall automatically be in the closed position during starting-up until the pre-selected fan speed is reached.
- 4.2.2.14 Casing access panels shall be fitted to fans 630mm and larger and all fans used in draw-through applications with spray coolers or sprayed coils.
- 4.2.3 Axial Flow Fans
- 4.2.3.1 Axial flow fans shall be of the aerofoil type with non-overloading characteristic with peak power requirements occurring in normal operating pressure range and motor rating exceeding this requirement.
- 4.2.3.2 Axial fans shall be selected for the highest possible efficiency with the lowest possible blade tip speed.
- 4.2.3.3 Only fans of a make approved by the Department will be acceptable.
- 4.2.3.4 The complete fan unit shall be statically and dynamically balanced in accordance with ISO 1940 - 1973 within grade G6,3.
- 4.2.3.5 Fan performance shall be based on tests carried out in accordance with BS 848 : Part 1 as amended.
- 4.2.3.6 Fan casings shall be manufactured from reinforced mild steel with predrilled flanges at both ends.
- 4.2.3.7 Casing access panels shall be provided where specified in the Supplementary Specification.
- 4.2.3.8 Fan motors shall be totally enclosed squirrel cage induction type with protection to IP 55 unless for a special application as set out in the Supplementary Specification.
- 4.2.3.9 Motor connections shall be in a external weather proof terminal box forming part of the casing. (Except for flameproof and special applications.)
- 4.2.3.10 Fans fitted at the inlet of a system shall be provided with bell-mouth entries.
- 4.2.3.11 Axial fans shall be resiliently mounted.
- 4.2.3.12 Single-phase fan motors shall only be provided where specifically specified in the Supplementary Specification.
- 4.2.3.13 Impeller hubs and blades shall be die cast aluminium alloy assembled with high tensile steel bolts and nuts except for special applications where material requirements will be as set out in the Supplementary Specification.

4.2.4 Propeller Fans

- 4.2.4.1 Propeller fans shall be suitable for mounting with or without mounting plate (diaphragm) as specified in the Supplementary Specification.
- 4.2.4.2 Mounting plates (diaphragm) where required shall be of pressed steel or reinforced laminated fibreglass with integral bell mouth orifice.
- 4.2.4.3 Impellers shall be of heavy gauge contoured pressed steel blades or reinforced polypropylene or fibreglass ultra-violet stabilised, mounted on cast aluminium or steel hubs.
- 4.2.4.4 Fan motors shall be three-phase totally enclosed squirrel cage induction type with protection to IP44 unless otherwise specified.
- 4.2.4.5 Fans shall be resiliently mounted.
- 4.2.4.6 Balancing and testing shall be as set out in clauses 4.2.3.4 and 4.2.3.5 above.
- 4.2.4.7 Motor and impeller protection screens shall be fitted as applicable.
- 4.2.4.8 Fans on exterior walls shall be fitted with weather tight galvanised louvre shutters and where specified with wall cowls.

4.2.5 Window/Wall Extract Fans

- 4.2.5.1 Window/wall type fans shall be fitted with automatic shutters.
- 4.2.5.2 Fans shall be fitted with finger protection guards.
- 4.2.5.3 Where specified, speed control shall be provided.
- 4.2.5.4 Where remote control is specified wiring between fan, control point and power supply point shall be flush mounted with conduit and draw boxes.

4.2.6 Roof Extract Fans

- 4.2.6.1 Roof extract fans shall be the mixed flow or propeller type as specified in the Supplementary Specification with non-overloading characteristic.
- 4.2.6.2 Where specified, units shall be suitable for upstand or curb mounting complete with weather skirt and flashing as required.
- 4.2.6.3 Vertical discharge fans shall be fitted with shutters to prevent rain ingress.
- 4.2.6.4 Roof extract units shall be suitable for mounting on any form of roof with pitch varying from horizontal to 45 degrees.
- 4.2.6.5 Roof extract units shall be manufactured from corrosion resistant materials and painted as specified.
- 4.2.6.6 Fans shall be directly driven by totally enclosed airstream rated motors protected to IP44 or as specified.
- 4.2.6.7 Fan performance shall be based on tests carried out in accordance with BS 848 : Part 1 (as amended).
- 4.2.6.8 Impeller shall be statically and dynamically balanced.

4.3.0 ELECTRICAL HEATERS

- 4.3.1 Heaters shall comply with the current issue of the Department's Standard Specification for Electrical Equipment and Installation for Mechanical Services and SABS 0173 as applicable.
- 4.3.2 Heaters built in to ductwork shall be provided with fibrecement panelling downstream of the heater bank as protection for the insulation in close proximity to the heater bank.
- 4.3.3 Heaters shall be so constructed and installed that routine maintenance, repair or replacement can be undertaken without disassembly of connected ducting or air handling plants.
- 4.3.4 The heater element for each step of heating shall be strung across the entire face of the coil or duct opening to prevent stratification and bypassing when operating at reduced capacity.
- 4.3.5 Ventilation and other openings in the external enclosure shall be so protected that contact with live terminals or parts is rendered impossible without the use of tools.

4.4.0 AIR FILTERS

4.4.1 General

- 4.4.1.1 Filters of the type, size and quantity as specified in the Supplementary Specification shall be provided.
- 4.4.1.2 Filter efficiency and arrestance shall be in accordance with ASHRAE Test Standard 52-76.
- 4.4.1.3 Filters and filter holding frames shall be of approved manufacture with standardised dimensions to enable replacement with equivalent filters of all recognised manufacturers.
- 4.4.1.4 Construction and manufacture of all components shall be such that under no circumstances any un-filtered air can by-pass filters or filter banks.
- 4.4.1.5 Sufficient space shall be allowed in front or behind filters, as applicable, to enable inspection and servicing.
- 4.4.1.6 Proper access doors shall be fitted to filter service areas.
- 4.4.1.7 Filters installed close to exposed air inlets shall be weather protected with weather louvres and a wire mesh screen.
- 4.4.1.8 Tubes for the measuring of the pressure drop across each filter bank shall be fitted as standard to enable connecting a manometer or other instrument as specified.
- 4.4.1.9 All filters and filter banks, including two-stage high efficiency and final filters shall be fitted with inclined pressure differential manometer gauges, clearly marked with filters clean (green) and filters dirty (red) indicators of a permanent type.

A separate manometer shall be fitted for each filter stage.
- 4.4.1.10 Fan and system selection shall allow for expected final filter resistance to ensure a supply air quantity in excess of 90% of design air quantity immediately prior to filter replacement.
- 4.4.1.11 Unless otherwise specified in the Supplementary Specification only dry media filters are required.
- 4.4.1.12 Where specified, pressure monitoring across a filter bank or banks shall be fitted for alarm purposes using differential pressure switches to activate the warning alarm or indicator required.
- 4.4.1.13 Where air filters of the washable type are specified in the Supplementary Specification a suitable filter wash tank and stand complete with a drying rack shall be provided in each plant room.

The wash tank and stand shall be manufactured from galvanised steel and epoxy powder coated.

The wash tank shall be connected to mains water and a suitable overflow and drain piped to the building drain fitted.

The drying rack shall hold at least 20 filters.

4.4.1.14 Where washable filters are specified one complete set of spare filters shall be provided.

4.4.2 Panel Filters

4.4.2.1 Panel filters shall be of the pleated type and not less than 50mm thick.

4.4.2.2 The filter shall be washable or disposable as specified.

4.4.2.3 Synthetic media shall be used bounded together with galvanised wire for reinforcing and bonded in the frame ensuring no air bypass.

4.4.2.4 The frame shall be galvanised steel or a distortion and corrosion free moulding.

4.4.2.5 Initial synthetic dust arrestance shall be not less than 70% with dust holding capacity needed in excess of 300g per square metre nominal face area.

4.4.2.6 Initial dust spot efficiency shall be not less than 20%.

4.4.2.7 Nominal filter face velocity shall not exceed 1,5m/s with initial clean filter resistance 60Pa or less and recommended resistance at specified arrestance not more than 250Pa.

4.4.3 Pad Type Panel Filters

4.4.3.1 Pad type panel filters shall make use of disposable replacement media of thickness as specified, but generally not less than 25mm thick.

4.4.3.2 Disposable media supplied and the filter in general shall comply with 4.4.2 above, unless otherwise specified.

4.4.3.3 The media shall be held in galvanised steel frames with galvanised steel screen supports on both sides. The downstream screen shall be fixed in the frame with the upstream screen removable.

4.4.4 Extended Surface Intermediate Efficiency Filters

4.4.4.1 Filter media shall be self-supporting, leak-free and stable under all airflow conditions.

4.4.4.2 Front frames shall be of aluminium, galvanised steel or reinforced high-density hard polyurethane foam with a continuous foam rubber gasket.

4.4.4.3 "Slide-in" type of arrangements will not be accepted for filters in this class.

4.4.4.4 Filter depths less than 150mm will not be accepted.

4.4.4.5 Galvanised protection screens shall be fitted to match the airflow arrangement.

4.4.4.6 Initial synthetic dust arrestance shall be not less than 85% with dust holding capacity not less than 1 500g per square metre nominal face area.

4.4.4.7 Nominal filter face velocity shall not exceed 2,5m/s with initial clean filter resistance 60Pa or less and recommended resistance at specified arrestance not more than 250Pa.

4.4.5 High Efficiency Particulate Air Filters (HEPA)

- 4.4.5.1 Filter media shall be self-supporting leak-free and stable under all airflow conditions.
- 4.4.5.2 The media shall be bonded in to a pressed and sealed particle board housing.
- 4.4.5.3 Unless otherwise specified in the Supplementary Specification filters shall be provided with silicone filled channel seals.
- 4.4.5.4 "Slide-in" type of arrangements will not be accepted for filters in this class.
- 4.4.5.5 Filters shall be arranged in two or three stage configuration with the primary filters complying with clauses 4.4.1 to 4.4.4 above as specified in the Supplementary Specification.
- 4.4.5.6 Filter depths less than 300mm will not be accepted and effective filter media surface area shall exceed 50m² per square metre nominal face area.
- 4.4.5.7 Each filter shall be individually tested in the factory for leakage with a DOP aerosol and supplied to site in completely sealed protection containers.
- 4.4.5.8 Corrugated media separators shall be of aluminium or kraft paper.
- 4.4.5.9 Filter efficiency shall be not less than 99,9% when tested with 0,3 micrometer Dioctylphthalate smoke.
- 4.4.5.10 Dust holding capacity shall not be less than 2 000g per square metre nominal face area.
- 4.4.5.11 Nominal filter face velocity shall not exceed 1,5m/s with initial clean filter resistance to be 250Pa or less and final resistance not to exceed 500Pa.
- 4.4.5.12 Pressure monitoring across the HEPA filters is required with warning light and/or alarm as specified.

4.4.6 Filter Holding Frames

- 4.4.6.1 Filter holding frames shall be the manufacturer's standard product installed and used in accordance with his recommendations.
- 4.4.6.2 Holding frames shall be manufactured from at least 16 gauge galvanised or epoxy powder coated steel.
- 4.4.6.3 Holding frames may be bolted or riveted together and shall be suitably reinforced in larger arrangements to withstand all possible operating conditions.
- 4.4.6.4 Fasteners shall be positive sealing type that clip in and a minimum of four fasteners per filter is required.
- 4.4.6.5 Fasteners shall match the particular filter, filter arrangement and frame.

4.5.0 COOLING AND HEATING COILS

4.5.1 General

4.5.1.1 Cooling coils shall be suitable for direct expansion air to refrigerant heat transfer or air to chilled water heat transfer as specified in the Supplementary Specification.

4.5.1.2 Heating coils shall be of the hot water to air heat transfer type.

4.5.1.3 Coils shall be of the extended surface type, constructed of seamless copper tubes with mechanically bonded aluminium or copper fins.

For coastal installations and all spray coil applications copper to copper construction is required.

4.5.1.4 Coils shall be designed and constructed for a test pressure of 1 400kPa or the system working pressure times 1,5, whichever is the greatest.

4.5.1.4 Coil face velocity shall be low enough to ensure that no water is carried over in the air stream, generally not more than 2,5m/s.

Where moisture carry-over may be a problem proper eliminators shall be fitted downstream of the coil.

4.5.1.6 Coil casings shall be flanged and constructed of 1,6mm or thicker sheet steel hot dip galvanised after manufacture.

4.5.1.7 Water coils shall be provided with air vent and drain connections. Drain connections and coil circuitry shall be such that the coil can be completely drained of water if necessary.

4.5.1.8 Tubes shall be silver soldered to headers.

4.5.1.9 All coils subject to mechanical damage shall be properly protected with galvanised sheetmetal covers over the entire coil face area. Covers shall only be removed when commissioning commences.

4.5.2 Direct Expansion Coils

4.5.2.1 Direct expansion coils shall be circuited for the most economic balance between heat transfer, refrigerant pressure drop and proper oil return.

4.5.2.2 The suction header shall be constructed to ensure complete oil drainage from the coil.

4.5.2.3 Liquid and vapour distributors on multi-circuit coils shall ensure uniform refrigerant distribution between circuits.

4.5.3 Heating Coils

4.5.3.1 Heating coils shall conform to the same requirements as cooling coils.

4.5.3.2 Steam heating coils shall be slightly tilted to ensure proper condensate drainage from the coil.

4.5.3.3 Steam coils shall be fitted with proper vacuum breakers.

4.5.4 Spray Coils

4.5.4.1 Where spray coils are specified a full-face area eliminator section shall be provided downstream of the coil section.

4.5.4.2 Eliminators shall be manufactured from uPVC or moulded fibreglass with a minimum of three directional changes to the air path and eliminator baffle spacing not exceeding 30mm.

- 4.5.4.3 Water distribution over the coil shall be by means of plastic, bronze or gunmetal nozzles of the centrifugal non-clog type spaced to ensure complete spray coverage over the entire coil face area.
- 4.5.4.4 A sump manufactured from stainless steel 430 shall be provided to collect spray run-off. The sump shall be provided with a brass float valve connected to the water mains and overflow and drain piped to the nearest building drain point.
- 4.5.4.5 A removable strainer manufactured from brass or stainless steel shall be fitted to the pump suction connection. The strainer perforations shall be small enough to protect the nozzle and pump impeller clearances.
- 4.5.4.6 A water bleed line shall be fitted to the pump discharge and piped to the building drain point via an open turndish for visibility. A manual throttling valve shall be fitted to this line.
- 4.5.4.7 Pump installation shall be such as to ensure a flooded pump suction arrangement.
- 4.5.5 Drain Pan
- 4.5.5.1 Drain pans to collect water condensing on the coil shall be provided under all cooling/ dehumidifying coils.
- 4.5.5.2 The pan shall be constructed from galvanised sheet steel or copper (1,6mm thick or thicker). Fibreglass moulded or uPVC welded drippans are acceptable.
- 4.5.5.3 The pan bottom shall slope from all sides towards the drain point.
- 4.5.5.4 The pan shall be fitted with a screwed drain connection 20mm or larger depending on coil size and application.

The drain connection shall be fitted with a manometric trap matching fan pressure but not less than 50mm water depth.
- 4.5.5.5 Coils shall be arranged so that all condensate water is collected with no air bypassing the coil.
- 4.5.5.6 Pans at risk of "sweating" on the outside and causing water dripping or collecting outside the pan where it cannot be properly drained away, shall be insulated.
- 4.5.5.7 The drain from the drippan shall be piped to the nearest building or plantroom drain with 20mm galvanised steel pipe (or copper) or larger.
- 4.5.5.8 Damming up of water or puddles of water anywhere in the air-handling unit will not be accepted.
- 4.6.0 HEAT PUMPS
- 4.6.1 Heat pumps shall be of the air-to-water, water-to-water or air-to-air type or as specified in the Supplementary Specification.
- 4.6.2 Refrigerant to water heat exchangers shall be corrosion resistant and suitable for use with the local water at high temperature and flow velocities.
- 4.6.3 Shell and tube condensers are preferred for air to water applications.
- 4.6.4 Heat pumps shall be completely self-contained units with stainless steel or epoxy powder coated casings and cladding, suitable for permanent outdoor use where required.
- 4.6.5 Condenser and condenser piping circuits shall be properly insulated.
- 4.6.6 A condensate drippan of stainless steel 430 shall be fitted and piped to the nearest building drain, allowing for defrost cycles.

- 4.6.7 Heat pumps shall be selected for a maximum compressor running operation of 20 hours per day.
- 4.6.8 Reverse cycle automatically controlled defrost shall be provided as standard. Defrost shall be demand controlled and not timer controlled.
- 4.6.9 The heat pump shall be suitable for operating with ambient wet bulb temperatures as low as -10°C and as high as 35°C.
- 4.6.10 Heat pumps for domestic hot water shall heat the water to 60°C (or as specified). Condensing and evaporation temperatures shall be selected to ensure correct functioning with water inlet temperature as low as 9°C and as high as 50°C. Heat pumps not capable of heating inlet water at 50°C will not be accepted.
- 4.6.11 Heat pumps with a coefficient of performance (COP) of less than 3,0 at ambient wet bulb temperature of 15°C with secondary circuit inlet temperature 20°C or less will not be acceptable.
- 4.6.12 Each heat pump shall be fitted with a control and a fault indication panel to provide status indication on fault occurrence and operation mode.
- 4.6.13 A flow switch shall be fitted to the water or air secondary circuit and the heat pump control interlocked with the flow switch.
- 4.6.14 Heat pumps for domestic hot water shall be fitted with head pressure control set at ensuring constant 60°C water supply temperature at all possible water inlet temperatures and flows.
- 4.6.15 Compressors shall be well known products of an approved manufacturer.

Motor windings shall be suitable for the temperatures experienced in heat pump applications, particularly hermetically sealed units.

Operating pressures and temperatures shall comply with the manufacturer's recommendations.
- 4.6.16 Provision shall be made in the refrigerant circuits for liquid collection during periods of not being in use.
- 4.6.17 The compressor shall be interlocked with the evaporator fan/s and the flow switch to prevent operation unless these elements are functional.
- 4.6.18 Each refrigerant circuit shall be fitted with a sight glass, replaceable filter drier, manual liquid shut-off valve, high- and low-pressure switches and pressure gauges.
- 4.6.19 Controls shall be fitted to prevent compressor short cycling on low demand.
- 4.6.20 Crankcase heaters shall be fitted where application and unit size warrants the use thereof.
- 4.6.21 Where a standby heater is required with a heat pump application the standby heater shall be switched on automatically on heat pump failure.
- 4.6.22 Suction- and discharge pressure gauges shall be provided on the instrument panel.
- 4.6.23 Noise levels shall comply with clause 3.15.0.
- 4.6.24 Easily detachable/ openable panels of rigid construction giving access to all working parts of the unit shall be provided.

4.7.0 SELF-CONTAINED AIR CONDITIONING UNITS

- 4.7.1 Each unit shall be complete with fan/s, direct expansion cooling coil, compressor unit, condenser (if not remote), expansion valve, refrigerant tubing and accessories, air filters, return air grille and/or mixing plenum control panel and control thermostat.
- 4.7.2 Units shall be totally indoor type or totally outdoor type as specified in the Supplementary Specification.
- 4.7.3 Condensers shall be air or water-cooled.
- Air cooled condensers may be remote (split) type with interconnecting refrigerant piping or built in to the unit with ducted air in- and outlets.
- Water cooled condensers may be remote evaporative cooling type or built in to the unit with water connections for connection to remote closed circuit or open cooling towers, as specified.
- 4.7.4 Where specified in the Supplementary Specification units shall be reverse cycle heating type.
- 4.7.5 Indoor units shall be suitable either for the attachment of ductwork or fitted with a discharge air plenum with adjustable directional air louvres (Automatic sweep acceptable) as specified. Return air shall similarly be ducted or through unit mounted return air grille as specified.
- 4.7.6 Outdoor units shall be suitable for ducted supply and return air with a proper mixing plenum, dampers and filter arrangement as indicated on the drawings.
- 4.7.7 The cabinet and dripan shall be of rigid galvanised sheet steel and angle iron construction epoxy powder coated. Units installed outdoors shall be totally waterproof.
- Units installed in visible locations indoors shall have a neat well-finished appearance.
- 4.7.8 Easily detachable panels giving free access to all components shall be provided.
- 4.7.9 The total interior of the cabinet shall be insulated with neoprene or sonic liner faced fibreglass at least 25mm thick (or other approved method of insulation).
- 4.7.10 Compressors shall be of the hermetically sealed or semi-sealed, reciprocating or rotary type.
- 4.7.11 Remote on/off control and sensing shall be provided where specified, and fitted in the position indicated on the drawings.
- 4.7.12 Indoor air supply fans shall be of the centrifugal type.
- 4.7.13 Outdoor fans (condenser fans) shall be of the centrifugal or axial flow type for ducted condenser air applications and propeller fans for free flow applications.
- 4.7.14 General arrangement and configuration required shall be indicated on the drawings.

4.8.0 FIELD ASSEMBLED AIR HANDLING UNITS AND PLENUMS

- 4.8.1 Field assembled plants shall consist of plenum chambers built to accommodate equipment such as dampers, filters, cooling- and heating coils, heating elements, fans, drain pan etc., as specified in the Supplementary Specification and/or drawings.
- 4.8.2 Plenum walls and roof shall consist of prefabricated precision metal clad insulated panels (double skin) with the metal skin permanently bonded to the insulation with heat polymerising adhesive.
- 4.8.3 Panel sections shall clip together or joined by means of male/female insertions with a non-hardening butyl rubber base sealant. Joints shall be sealed with a clear silicone sealant.

- 4.8.4 Panel insulation thickness shall be not less than 50mm based on polystyrene or 40mm based on polyurethane.
- 4.8.5 Panel finish shall generally be galvanised steel on the inside of the plenum and chromadek on the exterior. (Painted exterior panels acceptable.)
- 4.8.6 Panels for ventilating plants without heating or cooling can be single skin and uninsulated (where not exposed to heat sources) suitably reinforced to ensure a proper installation.
- 4.8.7 Floors for plenums shall be one of the following:
- i) Granolithic screed with steel trowelled finish, or
 - ii) Panel constructed as for walls (galvanised finish both sides) reinforced on top with 5mm thick aluminium checker plating, or
 - iii) As specified in the Supplementary Specification. Floors shall be waterproof and laid with a fall to the drain points.
- 4.8.8 Openings for doors, ducts, dampers etc. shall be pre-cut and neatly framed with angle iron steel and finished to match the exterior wall finish.
- 4.8.9 The entire plenum section shall be completely airtight and suitably reinforced to withstand all possible pressure differentials across the walls and roof sections.
- 4.8.10 Access doors shall be provided to all plenum sections. Doors shall be of the hinged double skin insulated type, 1600mm high and 600mm wide. Doors shall close airtight with sufficient cam lever type locking devices and a profiled durable rubber seal.
- 4.8.11 Detachable sections shall be provided for the removal or replacement of components such as fans, motors etc.
- 4.8.12 Standard factory fabricated modular central station air handling units may be offered as an alternative to field assembled units where such units match the general requirements set out above and the space requirements.
- 4.8.13 Doors giving access to electric heater banks shall be provided with safety micro switches to isolate all heater banks when these doors are opened.
- The following notice shall be painted on these access doors in clear red lettering at least 50mm high;
- "DANGER - ELECTRICAL HEATERS
GEVAAR - ELEKTRIESE VERWARMERS"
- 4.8.14 Coils, heaters, dampers etc. requirements shall comply with the relevant sections of this Specification.
- 4.8.15 Other factory made plenum designs will be considered subject to approval by the Department.

4.9.0 AIR HANDLING UNITS

- 4.9.1 Units and components shall generally comply with the relevant sections of this Specification.
- 4.9.2 Units shall be of the horizontal or vertical floor mounted type, draw-through or blow-through as specified in the Supplementary Specification.
- 4.9.3 For Operating theatres, Intensive care units, Burns units, Premature birth nurseries and the like only air handling units with blow through filter arrangements are acceptable.
- 4.9.4 Unit casings shall be heavy gauge galvanised sheet steel, suitably braced and stiffened to ensure a rigid non-vibrating structure.
- 4.9.5 Easily removable access panels shall be provided to facilitate servicing and repairs to items like fans, cooling and heating coils etc., and such panels shall be complete with suitable gaskets to ensure air tight fittings.
- 4.9.6 Solid double skinned access doors of the hinged type sealing air tight with proper hardware and profiled rubber seals shall be provided.
- 4.9.7 Doors giving access to electric heater banks shall be fitted with safety micro switches isolating the electricity supply to the heaters when such doors are opened. These access doors must be clearly marked in 50mm high red letters.
"DANGER - ELECTRICAL HEATERS
GEVAAR - ELEKTRIESE VERWARMERS"
- 4.9.8 The unit casing, together with removable panels, shall be internally insulated with 25mm thick polythene/neoprene coated glass fibre.
- 4.9.9 For Operating theatres, Intensive care units, Burns units, Delivery rooms, Premature birth nurseries and the like, the insulation shall be sheetmetal covered (Double skinned).
- 4.9.10 Where insulation is not sheet metal covered - i.e. it is not maintained between two sheets of metal, it shall be secured by means of a suitable adhesive as well as metal fasteners, spaced regularly at intervals not exceeding 0,3m.

4.10.0 FAN FILTER UNITS

- 4.10.1 Fan filter units shall be used to supply filtered air (usually outdoor air) for ventilation purposes as specified.
- 4.10.2 Filter requirements shall be as set out in the Supplementary Specification and in accordance with the relevant sections of clause 4.4.0.
- 4.10.3 Units shall be configured as indicated on the drawings.
- 4.10.4 Centrifugal fans only may be used in the units.
- 4.10.5 Casings shall be of galvanised sheet steel at least 1,25mm thick suitably reinforced and painted as specified.
- 4.10.6 Unless otherwise specified wall sleeves and weather louvres matching the fan filter unit shall be provided to form a complete installation.
- 4.10.7 Unit air supply shall be variable as specified by means of variable motor speed control and not damper control.

4.11.0 ROOM TYPE FAN COIL AIR HANDLING UNITS

- 4.11.1 Fan coil units shall be of the arrangement as indicated on the drawings i.e. concealed or exposed, floor mounted or ceiling mounted.
- 4.11.2 Each unit shall be complete with cabinet matching the application, chilled water cooling coil, hot water heating coil or electric element heater (as specified), fan, filter, drain pan, drain piping and controls.
- 4.11.3 Cabinets for exposed units shall be manufactured from 1,25mm thick sheet steel internally lined with glass fibre at least 12mm thick for insulation and acoustic purposes.
- A baked enamel finish to exposed surfaces shall be provided.
- Removable panels shall be provided to allow access for servicing of all components.
- 4.11.4 Units hidden from sight in bulkheads or ceilings shall be fabricated from 1,25mm galvanised sheet steel, internally lined with glass fibre at least 12mm thick for insulation and acoustic purposes.
- Motor and fan assembly shall be easily accessible for servicing.
- Where called for collars for supply and return ducting shall be fitted.
- Filters shall be accessible for cleaning or replacing.
- 4.11.5 Supply and return air grille shall be as specified.
- 4.11.6 Cooling and heating coils, and heating elements shall comply with the relevant sections of this Specification.
- 4.11.7 Fans shall be centrifugal type, statically and dynamically balance and directly connected to the drive motor.
- Fan wheels and housings shall be galvanised steel.
- 4.11.8 Fan motors shall be of the shaded pole or permanent split phase capacitor type with built-in thermal overload protection.
- 4.11.9 Drain pans shall be removable for cleaning purposes and shall be insulated to prevent condensation on the outer surfaces, and generally as per clause 4.5.5. The drain pan shall project under the entire length and width of the cooling coil including uninsulated portions of chilled water piping and valves.
- 4.11.10 Fan and unit on/off switch and controls shall be mounted on the unit or remote flush mounted as specified.
- 4.11.11 Fan control shall be by means of an on/off switch combined with speed selection options. A minimum of three speed selections shall be possible.
- 4.11.12 Cooling/heating control shall be by means of a thermostat and shall be on/off or proportional as specified.
- 4.11.13 Filters shall be easily accessible for cleaning and shall be of the cleanable type.
- 4.11.14 Outside air inlet openings with collars, sleeves, louvres and manual dampers shall be provided where specified.

4.12.0 INDUCTION UNITS

- 4.12.1 Except where otherwise specified in the Supplementary Specification the cabinets for induction units, with suitable discharge and return air grilles, will form part of the Building Contract.
- 4.12.2 Each unit shall be complete with air plenum, air balancing damper, ejector nozzles, cooling coil assembly, lint screen, drain pan and the necessary air and water connections.
- 4.12.3 The air plenum shall be constructed of cold rolled steel suitably rustproofed, or aluminium. All internal areas shall be acoustically and thermally insulated with fibreglass or equal. A primary air-balancing damper arranged for independent manual adjustment of the primary air volume shall be provided.
- 4.12.4 Ejector nozzles shall be heat resistant (65°C) and shall be designed for minimum noise generation and good flow characteristics. Nozzle pressure shall be such that the mean sound pressure levels of the units do not exceed the specified level.
- 4.12.5 Lint screens shall be of fine mesh, properly supported and readily removable for servicing.
- 4.12.6 Ducting and pipe work within the cabinets shall be properly supported.

4.13.0 EVAPORATIVE COOLING UNITS

4.13.1 Direct Evaporative Cooling Units

- 4.13.1.1 Evaporative cooling units shall be of the type and configuration indicated on the drawings and in the Supplementary Specification.
- 4.13.1.2 Unit casing shall be manufactured from galvanised sheet steel panels and galvanised angle iron framework bolted together.
- 4.13.1.3 Interior wet surfaces shall be epoxy coated against corrosion.
- 4.13.1.4 Exterior surfaces shall similarly be epoxy coated and then painted as specified.
- 4.13.1.5 Sufficient access doors and removable panels shall be provided to ensure access to all components.
- 4.13.1.6 Internal wiring shall be terminated in a weathertight junction box mounted on the outside of the unit.
- 4.13.1.7 Units shall be complete with fan/s, evaporative media (or nozzles), recirculating spray pumps, pump suction strainer, drain valve and overflow, automatic fill and level control, adjustable bleed valve, internal piping, sump and headers (or nozzles).
- 4.13.1.8 The unit shall have a saturation efficiency of not less than 80%, excluding pump and fan energy.
- 4.13.1.9 Evaporative media shall be of cross-fluted, self-cleaning design with a maximum face velocity of 3,8 m/s.
- 4.13.1.10 The media for rigid-media coolers shall be constructed of cellulose paper impregnated with insoluble anti-rot salts and rigidifying saturants.
- 4.13.1.11 Wetted pad type coolers may use fibrous fill of resilient material with a maximum nominal face velocity of 1,5 m/s, subject to approval by the Department.
- 4.13.1.12 Media shall be readily accessible for servicing and replacement.
- 4.13.1.13 The recirculating pump shall be of the centrifugal submersible type, corrosion proof and fitted with overload protection.

- 4.13.1.14 The fan shall be a centrifugal fan of corrosion proof materials.
- 4.13.1.15 Provision shall be made in all cases for the drainage and overflow to be piped to the nearest building drain by means of copper or uPVC tubing (Refer to Supplementary Specification) not less than 18 mm diameter.
- 4.13.1.16 Controls shall be as specified in the Supplementary Specification.
- 4.13.2 Two Stage Evaporative Cooling units
- 4.13.2.1 Two stage evaporative cooling units shall generally comply with 4.13.1 above and shall consist of a primary and secondary air stream, with the primary air dry cooled (sensible cooling) by a first stage cooling coil and second stage evaporative cooling.
- 4.13.2.2 The first stage coil shall be manufactured from copper tubing with aluminium or copper fins as specified in the Supplementary Specification and generally in accordance with clause 4.5.0.
- 4.13.2.3 Evaporative media shall be of crossfluted self-cleaning design with maximum face velocity of 3,5m/s.
- The media shall be manufactured from special cellulose paper impregnated with insoluble anti-rot salts and rigidifying saturants and not less than 300mm deep.
- 4.13.2.4 Water distribution piping shall be uPVC of class 4 or higher grade.
- 4.13.2.5 Fans for secondary air shall be as specified in the Supplementary Specification suitable for ducted or direct flow as required, with sealed bearings and IP54 or better in draw-through configuration.
- 4.13.2.6 Primary air fan shall be a centrifugal fan of corrosion proof materials.
- 4.13.2.7 Unless otherwise specified in the Supplementary Specification three step control will be required, i.e. first step no cooling with ventilation only, second step cooling as evaporative cooler only and third step as full two stage cooling unit, all controlled from a room sensor with the necessary controller.
- 4.14.0 ROOM TYPE AIR CONDITIONERS – WATER-COOLED
- 4.14.1 Room type water-cooled air conditioners shall generally comply with clause 4.1.0 and shall be of the direct expansion unitary design type with a water-cooled condenser for remote heat rejection.
- 4.14.1 Electrical interlocking shall be provided to ensure that:
- a) compressor cannot run without the indoor fan running and cooling water flowing. A flow switch shall be fitted in the water circuit of each individual unit to this end,
 - b) electric heating elements can only be switched on if the indoor fan is running,
 - c) it shall not be possible to switch on cooling and heating simultaneously.
- 4.14.3 Unit configuration and arrangement required shall be indicated on the drawings.
- 4.14.4 Units shall be completely self-contained and with isolating valves to connect condenser cooling water.
- 4.14.5 Units shall be fitted with hot water heating coils or electric heating elements as specified.
- 4.14.6 The water-cooled condenser shall be of the co-axial tube-in-tube type copper water path.
- 4.14.7 Water regulating valves for automatic head pressure control shall be fitted where specified.

4.15.0 RECIPROCATING REFRIGERANT COMPRESSORS

4.15.1 Reciprocating compressors shall be either of the open-, semi-hermetic- or hermetic type.

4.15.2 Compressors in the larger cooling capacity ranges shall be equipped with positive pressure lubrication systems.

4.15.3 Compressors shall be operated within the selection and speed ranges recommended by the manufacturer.

4.15.4 Provision shall be made to prevent excessive accumulation of liquid refrigerant in crank- cases during off-cycles.

Larger units shall be factory fitted with crankcase heaters as standard.

4.15.5 Compressors having nominal cooling capacities of 35 kW and larger shall be equipped with built-in capacity controlled steps (Depending on number of cylinders) of unloading cylinders.

4.15.6 Compressors with nominal cooling capacity exceeding 7 kW must start unloaded.

4.15.7 Open type compressors shall be directly coupled to the drive motor by means of flexible couplings.

Compressor and motor shall be mounted on a single robust bedplate of fabricated steel construction.

4.15.8 Multiple compressors connected to the same refrigerant circuit shall have the piping arranged to return oil equal to all compressors and balance lines shall be installed to equalise pressure differences between compressors.

The compressors must all operate at the same suction pressure.

4.15.9 Operating and safety controls shall be provided for each unit in a control panel forming an integral part of the unit or in a separate control panel/switchboard, as specified.

The following controls and instruments shall be provided as a minimum;

- a) Suction and discharge pressure gauges with isolating valves,
- b) Oil pressure gauge and low oil pressure safety switch on compressors with positive pressure oil feed,
- c) High- and low refrigerant pressure safety switches,
- d) Positive action timer controlled circuit for pump-down and to prevent short cycling,
- e) Sight glass indicating oil level in crankcase.

4.15.10 Units of 7 kW and larger shall be fitted with a suction strainer and an oil filter with replaceable element and safety by-pass.

4.15.11 Initial charge of oil and refrigerant shall be provided.

4.15.12 Internal motor over-temperature protection shall be fitted to hermetically and semi-hermitically sealed units together with external over-current protection.

4.15.13 Serviceable compressors shall be equipped with shut-off valves on the suction and discharge sides.

4.15.14 Compressor and components of 40kg or heavier shall be fitted with lifting lugs.

4.15.15 Tenders for compressors of a manufacture not adequately backed by South African suppliers carrying sufficient stock of the complete line of spare parts, which are subject to replacement, will not be considered.

4.16.0 RECIPROCATING COMPRESSOR WATER CHILLERS

4.16.1 The compressors shall generally be in accordance with clause 4.15.0.

4.16.2 Each water chiller shall be complete with one or more compressor and motor units, water cooler (evaporator), condenser, expansion valves, refrigerant piping circuits, controls and control panel.

4.16.3 The condenser shall be air-cooled or water cooled as specified.

4.16.4 The water chiller shall be a complete packaged unit with all components mounted on a sturdy steel framework with cladding, panels etc. to match the application.

4.16.5 Air-cooled chillers installed indoors shall be fitted with centrifugal or axial flow condenser fans.

4.16.6 The water cooler (evaporator) shall be of the shell-and-tube design with seamless copper tubing expanded into steel tube plating, each individually replaceable.

Tubes shall be accessible from either side of the shell for tube replacement and cleaning purposes.

Corrosion proof internal baffling shall be provided.

4.16.7 Chillers smaller than 30kW cooling capacity may be provided with copper to copper, tube-in-tube evaporators.

4.16.8 Waterside working pressure rating for the water cooler and condenser (where water-cooled) shall be not less than 1000 kPa.

4.16.9 Evaporators shall be factory insulated.

4.16.10 Step control shall be provided matching compressor/cylinder configuration.

4.16.11 Each evaporator unit shall be provided with a chilled water low temperature safety switch.

4.16.12 Compressor control shall be interlocked with a flow-switch in the chilled water circuit (with delay timer) to prevent the unit operating with no water flow.

4.16.13 Multiple compressor and refrigerant circuit units shall be provided with automatic controls for lead/lag switching and operating time balancing of compressor running hours.

4.16.14 Units shall be selected with fouling factors as required in the Supplementary Specification.

4.17.0 CENTRIFUGAL COMPRESSOR WATER CHILLERS

4.17.1 Centrifugal compressor chillers shall be of the packaged type complete with built-up water cooler and condenser, centrifugal compressor, capacity control system, lubrication system, purge system, all interconnecting piping, controls and all other auxiliaries required for the proper and safe operation of the unit.

4.17.2 Rotor assemblies shall be statically and dynamically balanced and shall be free from vibration at all operating conditions, also during acceleration from rest and deceleration from operating speed to rest.

Operating speed shall be well below the first critical speed.

- 4.17.3 Each compressor unit shall be equipped with a forced lubrication system complete with oil pump, reservoir, oil heater, oil cooler, filter, level indicator etc. which shall provide positive lubrication of all moving parts under all operating conditions, including start-up and shut-down operations.
- 4.17.4 Units operating below atmospheric pressure shall be provided with a motor driven purge pump or compressor complete with the necessary accessories for the automatic separation of non-condensable gasses and the return to the evaporator of reclaimed refrigerant.
- 4.17.5 Each unit shall be provided with a control panel or cabinet containing the main switch, circuit breakers, refrigerant pressure gauges, high and low pressure and low temperature cut-out safety switches, a differential oil pressure safety switch and all other accessories required for the proper and safe operation of the unit.
- 4.17.6 Units operating above atmospheric pressure shall be provided with a separate compressor operated transfer unit and storage tank to permit removal and isolation of the full refrigerant charge allowing internal inspection of the evaporator, condenser and compressor.
- The transfer unit shall be complete with all necessary controls for manual operation including all piping and valves.
- 4.17.7 The chiller shall be capable of starting and operating at part load.
- 4.17.8 Stable capacity control through a range of 10% to 100% of full load by means of variable inlet vanes shall be provided.
- 4.17.9 Thermometers shall be provided as permanent equipment on all compressor and gearbox bearings to indicate the prevailing bearing or lubricant temperatures.
- 4.17.10 The water cooler (evaporator) shall generally be of the shell and tube type as specified for the reciprocating compressor water chillers.
- 4.17.11 Condensers shall be of the water-cooled shell and tube type.
- 4.17.12 Evaporators shall be provided with charging connections, relief devices and sufficient eliminator area to prevent liquid refrigerant carry-over.
- 4.17.13 Operating and safety controls shall be provided on the control panel or cabinet supplied with each unit. The following instrumentation shall be provided as a minimum;
- a) Microcomputer control system,
 - b) Suction and discharge refrigerant pressure gauges,
 - c) Oil pressure gauge, (or LED readout)
 - d) Oil temperature gauge, (or LED readout)
 - e) Low chilled water temperature safety switch,
 - f) Low oil pressure safety switch,
 - g) Low- and high refrigerant pressure safety switches,
 - h) Bearing high temperature safety switch (manual reset),
 - i) Motor winding high-temperature safety switch (manual reset),
 - j) Necessary relays and time delays, including motor overload protection,
 - k) Ammeter. (3-phases)

- 4.17.18 Each compressor shall be driven by a squirrel cage induction type electric motor. The motors of hermetic units shall have insulation suitable for the service. It shall be either refrigerant gas cooled or water-cooled and shall be provided with a moisture indicator.
- 4.17.19 Waterside working pressure rating for water cooler and condenser shall be not less than 1000 kPa.
- 4.17.20 Units shall be selected with fouling factors as required in the Supplementary Specification.
- 4.17.21 Initial charge of oil and refrigerant shall be provided.
- 4.17.22 The water chiller shall be a complete packaged unit with all components mounted on a sturdy steel framework with cladding, panels etc. to match the application.
- 4.17.23 Evaporators shall be factory insulated.
- 4.17.24 Compressor control shall be interlocked with a flow switch (with delay timer) in the chilled water circuit to prevent the unit operating with no water flow.
- 4.17.25 Mechanical means shall be provided to prevent loss of efficiency and impeller damage due to liquid carry-over.
- 4.17.26 Condenser tubes shall be protected against direct impingement of high velocity compressor discharge gas.
- 4.17.27 Initial charge of oil and refrigerant shall be provided.
- 4.18.0 SCREW COMPRESSOR WATER CHILLERS
- 4.18.1 Screw compressor chillers shall be of the serviceable hermetic compressor, direct drive packaged type complete with screw compressor, water cooler, condenser, capacity control, lubrication system, all interconnecting piping, control panel and all other auxiliaries required for the proper and safe operation of the unit.
- 4.18.2 Motor and rotor assemblies shall be statically and dynamically balanced and shall be free from vibration at all operating conditions.
- 4.18.3 Capacity control shall be by means of a hydraulic slide valve on a continuous basis or equal.
- 4.18.4 Bearing elements shall be pressure lubricated.
- 4.18.5 Low oil circulation rate shall be provided by means of an efficient oil separator forming an integral part of the compressor assembly.
- 4.18.6 The drive motor shall be refrigerant cooled.
- 4.18.7 Oil circulation system shall be complete with separator, compressor oil injection, oil filter, solenoid valves, flow switch, oil cooler, etc.
- 4.18.8 The water cooler (evaporator) shall be of the shell and tube type as specified for the reciprocating compressor water chillers.
- 4.18.9 The condenser shall be a water-cooled shell and tube condenser.
- 4.18.10 Water side working pressure rating for water cooler and condenser shall be not less than 1000 kPa.
- 4.18.11 The water chiller shall be a complete packaged unit with all components mounted on a sturdy steel framework with cladding, panels etc. to match the application.
- 4.18.12 Evaporators shall be factory insulated.

- 4.18.13 Each evaporator shall be provided with a low temperature safety switch.
- 4.18.14 Compressor control shall be interlocked with a flow switch in the chilled water circuit (with delay timer) to prevent the unit operating with no water flow.
- 4.18.15 Units shall be selected with fouling factors as required in the Supplementary Specification.
- 4.18.16 Each unit shall be provided with a control panel or cabinet containing the main switch, circuit breakers, refrigerant pressure gauges, high and low pressure and low temperature cut-out safety switches, low oil pressure safety switch and all other accessories required for the proper and safe operation of the unit.
- 4.18.17 The drive motor shall drive the male rotor assembly directly and shall be of the squirrel cage induction type.
- 4.18.18 Operating and safety controls shall be provided on the control panel or cabinet supplied with each unit. The following instrumentation shall be provided as a minimum;
- a) Microcomputer control system,
 - b) Suction and discharge refrigerant pressure gauges,
 - c) Oil pressure gauge (or LED readout),
 - d) Oil temperature gauge (or LED readout),
 - e) Low chilled water temperature safety switch,
 - f) Low oil pressure safety switch,
 - g) Low- and high refrigerant pressure safety switches,
 - h) Bearing high temperature safety switch (manual reset),
 - i) Motor winding high-temperature safety switch (manual reset),
 - j) Necessary relays and time delays, including motor overload protection,
 - k) Ammeter (or digital readout), 3 phases.
- 4.18.19 Initial charge of oil and refrigerant shall be provided.
- 4.19.0 SCROLL COMPRESSOR WATER CHILLERS
- 4.19.1 Scroll type compressor water chillers and components shall generally comply with the requirements set out for reciprocating compressor chillers.
- 4.19.2 The chiller shall be air-cooled, air cooled remote condenser or water cooled as specified.
- 4.19.3 The unit shall be free of liquid refrigerant and oil slugging.
- 4.19.3 Lubrication shall be by means of mechanical oil pump, complete with oil heater.
- 4.19.4 Evaporators and water-cooled condensers shall be shell and tube design.
- 4.19.5 The water chiller shall be a complete packaged unit with all components mounted on a sturdy steel framework with cladding, panels etc. to match the application.
- 4.19.6 Each chiller shall be complete with one or more compressor and motor units, water cooler (evaporator), condenser, expansion valves, refrigerant piping circuits, controls and control panel.

- 4.19.7 Evaporators shall be factory insulated.
- 4.19.8 Each evaporator unit shall be provided with a chilled water low temperature safety switch.
- 4.19.9 Compressor control shall be interlocked with a flow switch (with delay timer) in the chilled water circuit to prevent the unit operating with no water flow.
- 4.19.10 Operating control shall include for anti-recycling timing between compressor starts and capacity steps and low pressure starting.
- 4.19.11 Multiple compressor and refrigerant circuit units shall be provided with automatic controls for lead/lag switching and operating time balancing of compressor running hours.
- 4.20.0 AIR-COOLED CONDENSERS
- 4.20.1 Air-cooled condensers shall be complete factory assembled packaged units consisting of refrigerant condensing coils, framework, casing, fan/s and fan motor/s.
- 4.20.2 For coastal applications condensers shall be manufactured in accordance with clause 4.1.2.
- 4.20.3 Units shall be arranged for horizontal or vertical airflow as indicated on the drawings.
- 4.20.4 Units with ducted air discharge shall be fitted with centrifugal or axial flow fans.
- 4.20.5 Wiring shall be terminated in a weathertight junction box mounted in an accessible position on the unit.
- 4.20.6 Head pressure control with fan cycling and/or fan speed control shall be fitted as standard equipment.
- Idle fans shall not be driven backwards by air short-circuiting.
- 4.20.7 Condenser casings shall be constructed of galvanised steel, stainless steel or aluminium and painted. All steel parts shall be adequately protected against corrosion. Access panel doors shall be provided for repairs and maintenance.
- 4.20.8 Condensing coils shall be of seamless copper tubing with copper or aluminium fins depending on the application.
- Inlet headers shall be designed for uniform gas distribution through all individual circuits.
- Headers shall be arranged to prevent trapping of oil. The coil face velocity shall not exceed 3m/s.
- 4.20.9 Units for outdoor use must be suitably weather proofed. Fan blades shall be of aluminium or of steel having a corrosion resistant coating, including fan shafts.
- 4.20.10 Air intake and discharge openings shall be screened to protect coils and fins.
- 4.20.11 Heat rejection capacity and coil sizing shall be selected to ensure subcooling of refrigerant.
- 4.20.12 Interlocks for fans shall be provided between the indoor and outdoor units.

4.21.0 EVAPORATIVE CONDENSERS

- 4.21.1 Evaporative condensers shall be factory assembled sectional units, complete with fan/s, refrigerant condensing coil/s, spray nozzles and water distribution system, recirculating spray pump, eliminators, pan section and casing.
- 4.21.2 Heat rejection capacity and condenser section shall be selected for refrigerant subcooling.
- 4.21.3 Water level control shall be automatic with a quick-fill bypass valve and drain valve fitted to the sump.
- 4.21.4 Unless otherwise specified in the Supplementary Specification the unit shall be of the counter-flow blow-through arrangement type with centrifugal fan/s.
- 4.21.5 All steel sections shall be manufactured from galvanised steel with edges protected against corrosion.
- 4.21.6 Casings shall be rigidly manufactured from galvanised sheet steel, aluminium or re-enforced moulded glass fibre. Glass fibre units used outdoors shall be ultra-violet resistant.
- Access to all internal parts shall be provided by means of easily removable panel/s or watertight doors fitted with quick opening catches. Suitable handles or holding bars shall be fitted to removable panels and doors.
- 4.21.7 Fan wheels and housings shall be of hot dip galvanised steel or corrosion protected to the Department's approval.
- 4.21.8 All moving parts shall be protected with removable screens and panels, hot dip galvanised after manufacture.
- 4.21.9 Effective eliminator sections, corrosion proof shall be provided to prevent water carry-over.
- 4.21.10 Refrigerant inlet and outlet headers shall be arranged to ensure proper refrigerant distribution and complete drainage of any oil present.
- 4.21.11 The heat transfer coil shall be of heavy class seamless steel tubing to SABS 62, hot dip galvanised after manufacture. (Copper for coastal and high corrosion applications).
- 4.21.12 The pan section shall be manufactured of heavy gauge hot dip galvanised steel.
- Standard pan accessories shall include access doors, easily removable corrosion proof strainer for the pump suction, drain valve, overflow and large bore adjustable make-up ball valve.
- The perforations of the strainer shall be smaller than the bore of the spray nozzles.
- 4.21.13 Automatic water treatment for corrosion protection with bleed control shall be fitted as standard equipment.
- 4.21.13 Re-circulating spray water shall be uniformly distributed over the condensing coil ensuring complete wetting of the coil at all times.
- Spray nozzles shall be of the non-clogging type. Nozzles and branch piping shall be easily removable for cleaning and flushing purposes.
- 4.21.15 Evaporative condensers with ducted discharge shall be provided with access panels in the ducting, large enough to ensure proper access to nozzles and headers and to enable removal of eliminator sections for repairs or replacement.
- 4.21.16 The re-circulating pump shall be of the centrifugal type matching the system flow and pressure requirements.
- A pressure gauge shall be fitted to the pump discharge.

The pump shall be installed in such a manner that it will drain completely when the sump is drained.

- 4.21.17 Units for outdoor use shall be completely weatherproof including all electric components.
- 4.21.18 Units shall be assembled with compatible galvanised or polymer and cadmium coated fasteners.
- 4.21.19 Where specified in the Supplementary Specification protection against pan freezing shall be built in.
- 4.21.20 Head pressure control by means of modulating damper control matching heat rejection and system load shall be provided.
- 4.21.21 The unit shall be painted as set out in clause 3.13.11.
- 4.21.22 Drain and overflow connections shall be piped to the nearest building drain point or gully.
- 4.21.23 Interlocks for fans and pumps shall be provided between the indoor and outdoor units linked in the system as specified.
- 4.21.24 Wiring shall be terminated in a weathertight junction box on the unit.

4.22.0 WATER COOLED CONDENSERS

- 4.22.1 Water-cooled condensers smaller than 30 kW heat rejection may be copper, tube-in-tube type.
- 4.22.2 Water cooled condensers larger than 30 kW heat rejection shall be of the shell-and-tube design with seamless copper tubing expanded in to steel tube plating, each individually replaceable.

Tubes shall be accessible from either side of the shell for tube replacement and cleaning purposes.
- 4.22.3 Water-cooled condensers shall be fitted with the manufacturer's standard head pressure control.
- 4.22.4 Steel shells shall be welded to the tube plates.
- 4.22.5 Safety pressure relief valves shall be fitted.
- 4.22.6 Waterside shall be designed for a working pressure of 1000 kPa, refrigerant side to match the system.
- 4.22.7 Sub-cooling of refrigerant shall be built in as standard.
- 4.22.8 Mechanical means shall be provided in each condenser to avoid direct impingement of high velocity compressor discharge gas on the tubes.
- 4.22.9 The water velocity inside condenser tubes shall not exceed 3m/sec and the tube diameter shall not be less than 13mm I.D. Each condenser shall be provided with a main liquid stop valve.
- 4.22.10 A plastic resin coating or equal for corrosion protection shall be applied after fabrication to the waterside of all steel tube plates within each condenser.
- 4.22.11 Tube supports, correctly spaced shall be provided between the end plates.
- 4.22.12 End covers shall be of cast iron or welded steel with integral baffled circuiting to suit the pass arrangements.
- 4.22.13 End covers shall be provided with proper gaskets and shall be easily removable for periodic cleaning.
- 4.22.14 Water and refrigerant pipe connections shall be sized according to the duty and shall be flanged.
- 4.22.15 The unit shall be painted as set out in clause 3.13.11.

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4.23.0 COOLING TOWERS

- 4.23.1 Cooling towers shall be factory assembled units, rigidly constructed of galvanised sheet steel, stainless steel, aluminium or moulded fibre glass suitably reinforced with galvanised steel angle iron.
- Units shall be complete with fan/s, spray nozzles, water distribution system, eliminators, pan section and casing.
- 4.23.2 Water level control shall be automatic with a quick-fill bypass valve and drain valve fitted to the sump.
- 4.23.3 Unless otherwise specified in the Supplementary Specification the unit shall be of the counter-flow blow-through arrangement type with centrifugal fans.
- 4.23.4 All steel sections shall be manufactured from galvanised steel with edges protected against corrosion.
- 4.23.5 Access to all internal parts shall be provided by means of easily removable panel or watertight doors fitted with quick opening catches. Suitable handles or holding bars shall be fitted to removable panels and doors.
- 4.23.6 Fan wheels and housings shall be of hot dip galvanised steel or corrosion protected to the Department's approval.
- 4.23.7 All moving parts shall be protected with removable screens and panels, hot dip galvanised after manufacture.
- 4.23.8 Effective eliminator sections, corrosion proof shall be provided to prevent water carry-over.
- 4.23.9 The pan section shall be manufactured of heavy gauge hot dip galvanised steel.
- Standard pan accessories shall include access doors, easily removable corrosion proof strainer for the pump suction, drain valve, overflow and large bore adjustable make-up ball valve.
- The perforations of the strainer shall be smaller than the bore of the spray nozzles.
- 4.23.10 Automatic water treatment for corrosion protection with bleed control shall be fitted as standard equipment.
- 4.23.10 Recirculating spray water shall be uniformly distributed over the heat transfer surfaces ensuring complete wetting of the wet deck areas at all times.
- Spray nozzles shall be of the non-clogging type. Nozzles and branch piping shall be easily removable for cleaning and flushing purposes.
- 4.23.12 Cooling towers with ducted discharge shall be provided with access panels in the ducting, large enough to ensure proper access to nozzles and headers and to enable removal of eliminator sections for repairs or replacement.
- 4.23.13 A pressure gauge shall be fitted to the nozzle inlet piping from the pump.
- 4.23.14 Units for outdoor use shall be completely weatherproof including all electric components.
- 4.23.15 Units shall be assembled with compatible galvanised or polymer and cadmium coated fasteners.
- 4.23.16 Where specified in the Supplementary Specification protection against pan freezing shall be built in.
- 4.23.17 Where specified modulating damper control matching heat rejection and system load shall be provided.

- 4.23.18 All steel surface shall be painted as specified in Clause 3.13.11.
- 4.23.19 Cooling towers with forced draught propeller or axial flow fans are not acceptable.
- 4.23.20 Units with multiple fan sections shall be internally baffled to permit independent operation of the individual fan sections.
- 4.23.21 The wet deck shall consist of heavy hot dip galvanised steel, PVC or other plastic material impervious to rot or biological attack or decay encased in removable hot dip galvanised steel panels or sections.
- The wet deck surface shall be properly degreased.
- 4.23.22 Eliminators shall be manufactured from hot dip galvanised steel, stainless steel or moulded fibre glass UV stabilised where exposed to the sun with a minimum of three directional changes to the air path.
- Plate spacing shall not exceed 30mm centre to centre.
- 4.23.23 Drain and overflow connections shall be piped to the nearest building drain point or gully.
- 4.23.24 Cooling tower and circulating pump levels shall be arranged to ensure a flooded pump suction with NPSH complying with the manufacturer's requirements.
- 4.23.25 Piping system and cooling tower shall be arranged to prevent the sump flooding when circulating pumps are stopped.
- 4.23.26 Interlocks for fans and pumps shall be provided between the indoor and outdoor units linked in the system, as specified.
- 4.23.27 Wiring shall be terminated in a weather tight junction box on the unit.
- 4.24.0 CLOSED CIRCUIT COOLING TOWERS
- 4.24.1 Closed circuit cooling towers shall generally comply with clauses 4.22.0 and 4.23.0 as applicable.
- The heat exchanger shall however be water/fluid to water and not refrigerant to water.
- 4.24.2 Each tower shall be served by two circulating pumps, one for the closed circuit to be cooled and one forming an integral part of the cooling tower for the spray circuit.
- 4.24.3 The closed circuit shall be fitted with the necessary air release valves, expansion tank with make-up, overflow and drain connections and provision for slug-dosing of the closed circuit against corrosion.
- 4.25.0 DRY COOLERS
- 4.25.1 Dry coolers shall be factory assembled closed circuit water to air coolers, complete with heat exchanger, fan/s, screens and controls.
- 4.25.2 Heat rejection shall be based on ambient air to water or ambient air to glycol water solution where specified in the Supplementary Specification.
- 4.25.3 Drycooler selection shall be based on specified ambient dry bulb temperature and maximum circuit heat rejection.
- 4.25.4 Drycoolers shall be factory assembled, tested, commissioned and guaranteed.
- 4.25.5 Drycooler and circulating pumps shall be interlocked with the chiller/condenser with timer controlled delay starting of approximately 60 seconds (Adjustable 30 - 120 seconds).

- 4.25.6 The drycoolers shall be of the vertical or horizontal type with slow speed multiple fans of the direct drive type with horizontal or vertical air discharge as indicated on the drawing, suitable for permanent outdoor use.
- 4.25.7 The drycooler heat exchanger shall be constructed of copper tubing with aluminium fins (copper fins for coastal applications). Design water pressure shall be not less than 1400 kPa.
- 4.25.8 The casing shall be constructed of corrosion resistant steel, aluminium or stainless steel panels suitable for permanent outdoor application.
- If not stainless steel the casing shall be epoxy powder coated finish.
- 4.25.9 All sections of the casing shall be completely self-draining with no water collecting areas.
- 4.25.10 Support framework shall be hot dip galvanised after manufacture and epoxy powder coated.
- 4.25.11 The fans shall be direct drive type fitted with rigid protection screens on the discharge side and coils/fins similarly protected.
- Fans and fan motor shall have permanently sealed and lubricated ball or roller bearings, designed and manufactured for continuous heavy duty application.
- The drycoolers shall operate at minimum noise level with maximum fan speeds not exceeding 1000r/min.
- Fan blades shall be of aluminium or corrosion protected steel including shaft.
- 4.25.12 Tube headers shall be fitted with automatic air vent valves and drain valves as well as suitable in/out water connections.
- 4.25.13 Solid state fan speed control and fan cycling control on multiple fan units is required to maintain a near constant water temperature.
- 4.25.14 Off-cycle fans shall be protected against windmilling.
- 4.25.15 Coil face air velocity shall not exceed 3m/s.
- 4.25.16 The drycooler shall be mounted on a sturdy base frame and concrete plinth.
- 4.25.17 Internal wiring shall be terminated in a weather tight junction bore mounted on the unit baseframe.
- 4.26.0 CLOSED CIRCUIT, SECONDARY CIRCUITS
- 4.26.1 Proper provision shall be made in closed circuit secondary cooling circuits on the pump suction manifold for sampling and charging the circuit with glycol and corrosion inhibitor as required.
- 4.26.2 Systems shall be charged initially with a concentration by mass of non-corrosive glycol ethylene suitable for the application, where specified.
- 4.26.3 Systems shall also be charged with a recognised corrosion inhibitor chemical treatment of a reputable and recognised firm. This inhibitor shall match the corrosion characteristics of the site water, the glycol ethylene (where specified) and the piping system, including heat exchanger materials.
- It will also be expected of the Contractor during the 12-month maintenance guarantee period to sample the closed circuits, correct the concentration and inhibitor content as necessary and file a report on the state thereof with the maintenance report.

4.27.0 COMPUTER ROOM AIR CONDITIONING UNITS

4.27.1 Computer room type air conditioning units shall be of the remote air cooled, water/glycol cooled or chilled water cooled type as specified in the Supplementary Specification.

4.27.2 Down-flow or up-flow cabinet units shall be provided as indicated in the Supplementary Specification.

4.27.3 The units shall be of the free standing type suitable for mounting on a suspended computer type floor.

All units shall run continuously, capacity to be based on parallel redundancy.

Each unit shall be complete with compressor/s, water/glycol cooled or air cooled condenser and evaporator coils or chilled water coils, fan/s, electric heaters, filters, humidifier, refrigerant circuit and built-in controls with alarms and switchboard.

4.27.4 The units shall operate on 100% recirculating air and shall be near sensible coolers only. Air coil off temperature shall be maintained at set point temperature for normal operation, but the temperature shall be automatically adjusted for dehumidification when required with automatic reheat to maintain room temperature.

4.27.5 All components shall be selected for continuous year round operation with maximum life expectancy.

4.27.6 Each unit shall be installed on a specially manufactured steel structure to the supplier's requirements and not directly on the floor structure. This steel support shall be properly earthed to the unit but shall be insulated from the floor matrix and the special floor earth.

This floor stand shall have adjustable legs for height setting to match the final surrounding floor level and shall be complete with vibration isolation pads.

4.27.7 Cabinets shall consist of a rigid corrosion resistant framework onto which components and exterior panels are fitted. The exterior panels shall be provided with pressure tight, non-perishable rubber seals. All hinges shall be invisible and all panels easily removable for service access. Exterior panels shall be insulated with 25mm thick closed cell foam insulation or equal.

4.27.8 The coil dripan shall be of stainless steel 430 and shall be insulated. Drainage piping shall be provided.

4.27.9 An adjustable air by-pass is required to enable exact air balancing on site where direct driven fans are tendered. Air discharge opening sizes and positions to be arranged with Principal Contractor on site, to be cut into floor panels.

4.27.10 Service access shall be possible to all components and a secondary screening panel is required for live electrical terminals etc.

4.27.11 Cabinet colour shall be approved by the Department prior to ordering but shall generally match the computer equipment.

4.27.12 Refrigerant units larger than 15 kW nominal cooling capacity shall have multiple independent refrigerant circuits with separate compressors, evaporators etc.

4.27.13 Compressors shall be of the hermetic or semi-hermetic serviceable type with suction gas cooled motor and shall be mounted on anti-vibration and noise isolators.

4.27.14 Each compressor unit shall be complete with built-in overloads, oil sight glass, manual reset high pressure switch, pump down low pressure switch, reversible oil pumps for forced feed lubrication, pumpdown control and service valves. Units with compressor crankcase heaters and suction line accumulators in lieu of pump down control will also be considered.

- 4.27.15 Each compressor unit shall be complete with suction line strainer-dehydrator, hot gas muffler, moisture indicator, sight glass, thermal expansion valve and cooling coil (evaporator). The cooling coil shall be at least four rows deep.
- 4.27.16 The design shall ensure quiet operation, with fan impellers statically and dynamically balanced, and running on self aligned sealed-for-life bearings. Each fan shall be driven by it's own motor.
- 4.27.17 Fan motors shall be of the heavy duty, drip proof or totally enclosed type, specially selected for quiet operation and reliability. Overload protection shall be provided.
- 4.27.18 For belt driven units the motors shall be mounted on adjustable slide bases. A minimum of two belts, each capable of transmitting the full power requirements shall be provided.
- 4.27.19 Even air distribution over the coil face is essential.
- 4.27.20 Condenser circuits shall be equipped with head pressure control, factory fitted.
- 4.27.21 Disposable panel filters with pleated surfaces shall be provided. Filter efficiency shall be not less than 95% arrestance generally as per clause 4.4.0.
- 4.27.22 Filters shall form an integral part with the fan coil unit and shall fit into self-centring frames with soft rubber seals. An external manometer shall be mounted on each filter bank clearly marked to indicate filter replacement resistance.
- 4.27.23 The filters shall be serviceable from either side of the unit without a ladder or platform.
- 4.27.24 A filter resistance switch with adjustable range shall be provided and wired for remote indication/monitoring as part of control and alarm system, with terminals to suit.
- 4.27.25 Each unit shall be fitted with the manufacturer's standard heater/ reheater (electrical).
- The element pack is to be arranged to give an efficient heat transfer to the air, easy accessibility for maintenance and to allow expansion of the elements without distortion.
- 4.27.26 Each unit shall be provided with a complete microprocessor type environmental control system that may be programmed at the unit for the various parameters with local visual display of operating modes and visual indication of alarm conditions.
- 4.27.27 Local monitoring and programming as well as L.E.D. numerical displays on a visible monitor panel on the front of the unit of the following functions are required;
- a) Current room temperature, °C
 - b) Temperature setpoint, adjustable 18°C - 30°C
 - c) Temperature sensitivity, adjustable 1°C - 5°C
 - d) Humidity setpoint, 40% - 60% relative humidity
 - e) Humidity sensitivity, adjustable 1% - 10% r.h.

- 4.27.28 The following normal operating modes shall be indicated as coloured L.E.D. status displays on the monitor panel;
- a) Heating
 - b) Cooling
 - c) Humidification
 - d) Dehumidification
- 4.27.29 The control system shall monitor unit operation and activate an audible and visual L.E.D. display on the unit monitor panel of the following alarms;
- a) High room temperature
 - b) Low room temperature
 - c) High room humidity
 - d) Low room humidity
 - e) High compressor head pressure (for each compressor, where applicable).
 - f) Filter resistance high
 - g) Reduced or loss of air flow
 - h) Humidifier alarm
- 4.27.30 A silence button shall be provided for the audible alarm but alarm displays shall remain until the alarm condition is corrected.
- A manual compressor sequence switch shall be provided to enable changing of the lead/lag sequence for multiple compressor units.
- 4.27.31 Proportional dehumidification control is required with reheating to maintain room conditions.
- 4.27.32 A battery back-up system is required to maintain unit set points in the event of a power interruption.
- 4.27.33 Where specified in the Supplementary Specification the control system shall be suitable for interfacing with a remote monitoring microprocessor. It shall also be possible to set or adjust all operating and alarm parameters for each individual unit from this remote microprocessor.
- 4.27.34 Stop/start push buttons as well as lamp test buttons shall be provided.
- 4.27.35 Terminals shall be provided for N.O. or N.C. dry contact interlocking with fire protection systems to enable switching off of the unit in the event of a fire.
- 4.27.36 Interlocking for stopping/starting and control purposes shall be provided between indoor and outdoor units where applicable.

4.28.0 AIR COOLED CONDENSING UNITS

- 4.28.1 Air-cooled condensing units shall be factory produced and tested units complete with compressor/s, fan/s, condenser/s and casing.
- 4.28.2 Compressor, condenser and unit casing shall generally comply with clauses 4.15.0, 4.19.0 and 4.20.0 as applicable.
- 4.28.3 Outdoor units shall be suitable for permanent outdoor use and fully weatherproof.

4.29.0 REFRIGERANT CIRCUITS

- 4.29.1 Refrigerant tubing shall generally be in accordance with SABS 1453: 1988: Copper tubes for medical gas and vacuum services with preferred sizes in accordance with SABS: 460 class 2 and shall be de-oxidised and dehydrated.
- 4.29.2 The tubing shall be seamless cold drawn copper tubing with soldered copper capillary fittings.
- 4.29.3 Piping/tubes, up to and including 10 mm diameter, may be jointed with the flaring method.

Other pipeline joints, shall be silver soldered or other approved hard solder. All soldered joints, on factory supplied equipment, shall be carefully checked before commissioning and remade if found damaged in transit. Silver solders shall be in accordance with SABS 23: 1973 and revisions.
- 4.29.4 Pipe sizing shall be as specified in the supplementary specification. Pipe size selections shall however be such as to produce moderately low velocities whilst, nevertheless, ensuring;
 - a) proper oil return to the compressor and minimising lubricating oil being trapped in the system.
 - b) practical lines without excessive pressure drops and with proper feed to evaporators.
 - c) prevent liquid refrigerant from entering the compressor during operation and at shutdown.
- 4.29.5 All plant room piping shall be thoroughly cleaned and painted with a heat resistant clear lacquer.
- 4.29.6 Piping shall be supported (unless otherwise indicated on the drawings) as follows:

Pipe Size(mm)	Max. distance between supports in meters
10 (and smaller)	0,6
10 – 18	1,0
22	1,5
28 – 35	2,0
42	2,5
54	2,75
67	3,0

- 4.29.7 Refrigerant piping shall be arranged so that normal inspection and servicing of the compressor and other equipment is not hindered. Locations where copper tubing will be exposed to mechanical damage shall be avoided.
- 4.29.8 Flexible metal vibration absorbers shall be fitted at compressor discharge and suction connections. Absorbers shall be installed at right angles to the direction of vibration. Hangers and supports where piping penetrates through walls shall be designed to prevent transmission of vibration to the building.

- 4.29.9 A hot gas muffler shall be installed as close to the compressor as possible in a position to prevent oil trapping.
- 4.29.10 Flash gas at the expansion valve shall be prevented. On systems with large pressure drops due to line friction or static head, liquid line subcooling shall be accomplished by the use of either liquid-suction heat exchangers, or subcooling sections in evaporative, air, or water-cooled condensers.
- 4.29.11 Subcooling coils in evaporative and air-cooled condensers shall be in accordance with clause 4.5.0. Receivers shall be provided in the liquid line between the condensing and subcooling coils.
- 4.29.12 Liquid-suction heat exchangers shall be of either the shell-and-tube or the tube-in-tube type. Liquid-suction heat exchangers shall not be used in systems using R-22 as refrigerant. A valved liquid bypass shall be provided around the heat exchanger.
- 4.29.13 Coils with more than one inlet or coils in which the individual circuits are not evenly loaded due to surface or air quantity variations shall be provided with separate expansion valves.
- 4.29.14 For evaporative or air cooled condensers each compressor circuit shall be equipped with a receiver with safety valve, isolating valves and purge cock, capable of holding the full volume of refrigerant in that circuit. Receivers shall be shaded from the sun.
- Receivers with pressure/volume rating qualifying as pressure vessels in terms of the Regulations of the Machinery and Occupational Health and Safety Act shall comply with all requirements of the Act and Regulations and shall be fitted with safety valves, purge cock, isolating valves, manufacturer's plates etc. as required by the Regulations.
- 4.29.15 For water-cooled condensers where the condensers are not of sufficient capacity to hold the full refrigerant charge, a receiver shall be installed in each circuit to hold the balance of refrigerant.
- 4.29.16 The liquid piping from the condenser to the receiver shall allow free drainage of the liquid. The condenser to receiver piping shall be as short as possible and shall be pitched towards the receiver with a minimum slope of 20mm per metre.
- 4.29.17 Oil separators shall be used in systems where it is impossible to prevent substantial absorption of refrigerant in the crankcase oil during normal operation or during shutdown periods. Oil separators shall be insulated to prevent it from acting as a refrigerant condenser. Provision shall be made to prevent drainage of condensed refrigerant into the crankcase.
- 4.29.18 A quality refrigerant drier shall be provided in the liquid line on all systems. Dryers shall be of the side inlet replaceable element type. Dryers shall be installed with a three-valve bypass for servicing and to allow partial flow on open compressor systems in order to reduce pressure drop. All the refrigerant shall flow through the drier on hermetic compressor systems. A reliable moisture indicator shall be provided for positive indication when the drier cartridge should be replaced.
- 4.29.19 A quality strainer shall be provided on all systems in the liquid line. A suction strainer shall also be provided unless the compressor is equipped with a built-in suction strainer. Combined filter-dryers are also acceptable. Strainers shall be adequately sized to assure adequate foreign material storage capacity without causing excessive pressure drop.
- 4.29.20 Sight glasses of double port seal cap type shall be installed in a vertical section of the liquid line after the receiver or condenser (if no receiver is used) to check the refrigerant charge and before the expansion valve to check the state of the refrigerant. Moisture indicators installed directly in the liquid line serving the dual purpose of liquid line sight glass and moisture indicator are also acceptable.
- 4.29.21 A refrigerant charging connection shall be provided between the receiver or shell and tube condenser and the refrigerant drier, in the liquid line. Before charging the system with refrigerant the circuit shall be tested as specified.

4.29.22 Solenoid valves shall have opening stems to continue operation of the system in case of solenoid coil failure.

4.29.23 All pipes, vessels etc. operating below ambient dew point shall be insulated and a vapour barrier provided.

4.30.0 WATER CIRCUITS AND ACCESSORIES

4.30.1 Piping

4.30.1.1 Piping layouts and circuits shall be laid out as shown on the drawings, including schematic drawings issued with the service.

4.30.1.2 Unless otherwise specified open circuit condenser cooling water piping shall be heavy class steel piping to SABS 62: 1971, amended and galvanised to SABS 763 : 1988 for type B articles, heavy duty.

4.30.1.3 Unless otherwise specified closed circuit condenser water piping, primary and secondary chilled water piping and closed circuit hot water piping for heating circuits shall be medium class black piping to SABS 62 : 1971, painted or coated as specified prior to insulation where applicable.

4.30.1.4 Where specified in the Supplementary Specification chilled water piping and condenser water piping up to size 50mm diameter may be copper piping.

Where specified in the Supplementary Specification condenser water piping may be uPVC not less than class 6 or as specified.

4.30.1.5 Pipe connections from main circuits to unitary equipment such as fan coils, humidifiers etc. shall be annealed copper class 2 to SABS 460 : 1985, as amended.

4.30.1.6 Fittings and accessories larger than 50mm nominal bore size shall be flanged with standard flanges to SABS 1123.

Compressed mineral fibre joint rings shall be used for flanged joint packings.

4.30.1.7 Fittings and accessories smaller than 50mm nominal bore may use screwed connections.

Screwed fittings shall be of malleable cast iron to SABS 509 : 1975, amended. Ordinary light type or black iron fittings shall not be used.

Screw thread shall be to BS21 of ISO R7.

PTFE sealing tape or other approved sealing compound shall be used on screwed connections.

4.30.1.8 Welding to galvanised piping or fittings will not be permitted.

Where welding for whatever purpose is unavoidable the complete section shall be hot dip galvanised after manufacture.

Cold galvanising will not be accepted.

4.30.1.9 Full radius bends and sweep fittings must be used wherever possible. Elbows may only be used under exceptional conditions and only with written permission of the Department.

Where it is necessary to reduce pipes in size, reducing sockets only shall be used and not bushes.

In horizontal runs of piping, where there is only a slight fall eccentric fittings are to be used.

4.30.1.10 Pressure relief valves shall be of Spirax or approved manufacture and shall be installed in the positions indicated on the drawings.

Pressure relief valve drains shall be taken to a suitable safe discharge point.

4.30.1.11 Where pipes pass through walls etc., sleeve pipes must be provided by the Contractor. Sleeve pipes should be made in such a manner that they will not foul against any piping due to the natural expansions and contraction of the piping.

4.30.1.12 All pipelines must be provided with 15mm drain cocks at all low points in the system so that the pipework can be drained of liquid without dismantling.

Sufficient drain points must be provided to drain the system completely.

4.30.1.13 Provision shall be made by tenderers in their tender price to have one in every twenty welded joints cut-out for inspection and testing and for making good afterwards.

Should any of the test welds prove unsatisfactory the Contractor will be called upon to have all welds on the installation X-rayed and examined, at his own expense, by an approved Inspection Authority.

The Contractor will then be required to submit written test and inspection reports by the Inspection Authority before the installation will be considered for acceptance.

4.30.1.14 Horizontal pipes shall be installed with a slope of at least 1 in 500 to allow venting of air to the expansion tank wherever possible. Air pockets shall be avoided. High points shall be provided with automatic air vent valves or air bottles. Air vents or bottles shall be designed for at least 1,5 times the working pressure of the system.

4.30.1.15 Piping in plant rooms shall be so arranged that normal inspection and servicing of equipment is not obstructed.

All pipes must be neatly fitted and shall be run in such a manner as to prevent the formation of air locks.

On all circuits, screwed unions or flanged joints are to be provided to allow for the easy dismantling of pipes. Unions or flanges must be provided at all Tee-offs and adjacent to all valves. Pipes up to 50mm nominal size may use unions but pipes larger than 50mm must be flanged. On straight or continuous runs of pipe, unions or flanges shall be provided at intervals not exceeding 20 metres.

4.30.1.16 Pipes which are not dimensioned on drawings shall be sized as follows:-

- a) The velocity shall not exceed 3m/s.
- b) The friction rate shall not exceed 140 kPa per 100m length.

The pressure drop through all circuits shall be approximately the same. If this cannot be achieved by pipe sizing alone due to excessive resultant velocities, throttling or balancing type valves shall be provided where required.

4.30.1.17 Pipe supports and the positions of anchors shall be such as to allow for movement due to pipe expansion and contraction or expansion joints in the building structure as applicable. Expansion joints, where required, shall be of the bellows type manufactured from stainless steel or may be of the Viking Johnson pipe coupling or equal where moderate expansion movements are to be accommodated. Expansion joints shall be rated at not less than 1,5 times the maximum working pressure in the system. Expansion joints in hot water piping shall be suitable for water temperatures up to 120°C.

4.30.1.18 Pipe hangers shall be of the spring, roller, chain or rod type. The maximum spacing of hangers and the minimum diameter of hanger rods shall be as follows:-

Nominal Pipe Size mm	Maximum Span m	Minimum Rod Diameter mm
25	2,2	10
40	2,8	10
50	3,1	10
80	3,7	14
90	4,0	14
100	4,3	16
125	4,9	16
150	5,2	20
200	5,8	22
250	6,7	22
300	7,0	22

4.30.1.19 High compression type thermal insulation such as hard wood timber of the same diameter as the required insulation shall be provided between hangers and chilled and hot water pipes.

4.30.2 Strainers

4.30.2.1 Water strainers shall be of the pot or angle type. Strainers shall be designed for not less than 1 000 kPa or 1,5 times the maximum system working pressure whichever is the greatest. Strainer screens shall be of bronze, monel metal or stainless steel and shall have the following maximum perforation sizes:-

Strainer Size mm	Perforation Size mm
2 – 50	0,8
65 – 150	1,6
200 – 300	3,2
over 300	6,4

4.30.2.2 The effective free area of the screen shall in all cases be not less than 3 times the cross sectional area of the inlet opening.

4.30.2.3 Strainers shall be installed in accessible positions where the strainers can be easily removed and cleaned.

4.30.3 Pressure Gauges and Thermometers

4.30.3.1 Pressure gauges shall be of the "Bourdon" type to BS 1780 with at least a 100mm dial and calibrated in kPa with the maximum range not exceeding 1,5 times the system working pressure. Forged brass or gunmetal gauge cocks must be fitted with each pressure gauge.

4.30.3.2 Thermometers shall be of the replaceable glass type with bronze casings, fitted into pockets for removal without draining the system. The thermometers shall be calibrated in °C and the scale length shall be at least 170mm. Pockets shall be of brass, filled with oil and shall be installed vertically.

On pipes smaller than 50mm diameter, pipe sizes must be increased locally to install the sockets.

4.30.4 Air Release Valves

4.30.4.1 Automatic air release valves shall be provided where shown on the drawings, but shall in addition also be fitted to piping at all high points and other places where air may accumulate. As these points depend on the installation of the system, full responsibility for fitting these valves rests with the Contractor.

4.30.4.2 Valves shall be of the inverted float type similar or equal to Honeywell, Braukmann or Spirax. They shall have either integral shut-off valves or be preceded by a lock shield valve.

4.30.4.3 Connections to the service pipe shall be made at the highest point to ensure complete venting. Valves shall be mounted with the inlet connection exactly vertical.

4.30.5 Drain Cocks

4.30.5.1 Drain cocks shall be of copper alloy and be of the screw down pattern type to BS2879 : 1957, Type A. They shall be fitted to all low points in the installation to ensure full draining of the system.

4.30.6 Valves and Non-Return Valves

4.30.6.1 Isolating valves, unless otherwise specified in the Supplementary Specification shall be Saunders Type A or Type KB diaphragm valves or equal fitted with suitable diaphragms and rated for at least 1 000 kPa working pressure and the system temperature.

Diaphragm valves shall be provided with hand wheels. Valves of 80mm and larger which are installed higher than 2 500mm above floor level, shall be provided with chainwheels and chains.

4.30.6.2 Where isolating valves of the gate type are specified it shall be of the type with solid or flexible wedges in accordance with SABS 664 and SABS 776. Valves of 80mm nominal bore and smaller shall be of bronze or gunmetal.

In lieu of gate valves, other types of valves may also be offered provided that bodies, temperature and pressure ratings are generally as specified for gate valves and that the fluid pressure drop for wide open valves does not exceed that of 40 diameters of pipe of the same size.

4.30.6.3 Diaphragm type valves and gate valves shall not be used for balancing or throttling purposes.

4.30.6.4 Unless otherwise specified in the Supplementary Specification balancing valves shall be similar or equal to the STA-T shut-off/balancing valves. Valves shall be provided with drain cocks with hose connections and two pressure cocks across each valve to enable measuring the flow rate. A differential pressure gauge to measure the pressure drop across all the valves in the system and a flow chart for each valve size used shall be provided by the Contractor at first handover.

4.30.6.5 Throttling valves shall be either plug, globe, angle or "Y" valves. Provision shall be made to prevent opening and closing of throttling valves by unauthorised persons once they are set.

4.30.6.6 Check valves shall be of the swing or lift type with seats of neoprene, gunmetal or stainless steel, discs of bronze, gunmetal or stainless steel and bronze or cast iron bodies, suitably rated for system pressure and temperatures.

4.30.7 General

4.30.7.1 Flexible connections shall be provided at all chiller and pump connections and where indicated on the drawings. These shall be of nylon reinforced moulded neoprene rubber with metal flanges at both ends. Metal reinforcing will not be accepted.

The flexible connections shall be of spherical or double spherical construction as per clause 3.15.0.

The flexible connections shall be installed strictly in accordance with the manufacturer's recommendations and shall be suitable for the system working pressures and temperatures.

4.30.7.2 Pressure gauges, thermometers and shut-off valves shall be provided in the following positions in each condenser water pipe circuit:

- a) A pressure gauge, thermometer and shut-off valve before and after each condenser and self-contained air conditioning unit.
- b) A shut-off valve at the in- and outlet of each cooling tower.
- c) A strainer shall be provided at the suction side of each pump.
- d) A pressure gauge before and after each strainer and at each pump discharge for pump units.
- e) A shut-off valve before each strainer and at each pump discharge for pump units.

4.30.7.3 Pressure gauges, thermometers, unions and shut-off valves shall be provided at the inlet and outlet of chilled water and central heating coils.

4.30.7.4 Strainers shall be provided upstream of coils and control valves.

4.30.8 Expansion Tanks

4.30.8.1 Expansion tanks shall be fitted to all closed circuit piping installations. The tank capacities shall be as specified in the Supplementary Specification but generally not less than 50 litres water capacity.

4.30.8.2 The tank shall be manufactured from at least 2mm galvanised sheet steel or be hot dip galvanised after manufacture. The minimum water level in the tank shall be kept at approximately 300mm from the bottom by means of a 20mm nominal size ball valve. A stopcock shall be provided in the make-up water line upstream of the ball valve.

The tank shall be provided with a separate quick filling connection, overflow, drain and a bolt-down lid with an air vent.

4.30.8.3 The expansion tank shall be installed at least 1 200mm above the highest point of the relevant water system.

4.30.9 Copper Piping

4.30.9.1 Where specified in the Supplementary Specification copper piping may be used for chilled water and/ or condenser water piping.

4.30.9.2 All piping shall be the best quality copper pipe of approved make, free from any defects. The sizes shall be indicated on the main drawings and no pipe of a smaller size than 15mm shall be used.

4.30.9.3 All piping shall comply with SABS 460 – 1985 as amended, either half hard Class 1, 2 or 3 piping as specified in the Supplementary Specification.

All piping shall be suitable for a working pressure of not less than 1 300kPa.

- 4.30.9.4 In general, Class 1 and 2 piping shall be used inside buildings while only Class 3 piping shall be used for underground services.
- 4.30.9.5 All fittings shall be of the best quality and shall and shall be correctly matched to the size of piping to which they are connected.
- 4.30.9.6 Capillary type copper bends, elbows, tees, reducers, etc. are preferred wherever possible. These must be silver soldered using hard solders complying with SABS 23 – 1992 as amended. The use of soft tin-lead is not permissible.
- 4.30.9.7 Where it is necessary to provide dismantled connections in the pipework use may be made of brass “Flarex “or “Conex” type fittings.
- 4.3.9.8 “Conex” type fittings will not be permitted for use with Class 1 piping or in underground use.
- 4.3.9.9 Brass fittings must be made from a grade of brass or gunmetal, which will not be subject to dezincification.
- 4.30.9.10 Full radius bend and sweep fittings must be used wherever possible. Elbows may only be used under exceptional conditions and only with the express permission of the Department.
- 4.30.9.11 Where it is necessary to reduce pipes in size, reducing sockets and fittings only shall be used and not bushes.
In horizontal runs of piping, where there is only a slight fall, eccentric reducing fittings are to be used to prevent air locks.
- 4.30.9.12 Where practical copper pipes, particularly in sizes up to 28mm shall be bent or set around corners or obstacles. Where pipes are bent or set proper bending springs or pipe bends shall be used. No flattening of pipes at bends or sets will be permitted.
- 4.30.9.13 On all circuits, screwed “Flarex” or “Conex” unions o flanged joints are to be provided to allow for easy dismantling of pipes. Unions or flanges must be provided at all major tee offs and adjacent to all valves. Pipes up to 50mm may use unions but pipes above 50mm must be flanged. On straight or continuous runs of pipes, unions or flanges shall be provided at intervals not exceeding 20 meters.
- 4.30.9.14 Horizontal copper piping shall be supported unless otherwise indicated on the relevant drawings, as follows:

DIAMETER	MAXIMUM SUPPORT SPACING METERS
15mm	1,8
22 – 28mm	2,4
34 – 54mm	3,0
76 – 108mm	3,6

“Unistrut “ copper piping shall be supported unless otherwise indicated on the drawings or in the specification. Pipe support hanger bolts and “U-bolts” shall in all cases be provided with lock nuts, which shall be brass or galvanised and must be arranged so as to cause no electrolytic corrosion of the copper pipe.

Where small bare copper pipes are chased in to brickwork or floors, they shall be first wrapped with suitable mineral fibre or glass fibre tape approximately 6mm thick.

4.30.10 uPVC Piping

- 4.30.10.1 Where applicable in the Supplementary Specification uPVC piping may be used for condenser water, above or below ground.
- 4.30.10.2 The class of piping to be used shall be as specified, but not less than class 6.
- 4.30.10.3 Piping, fittings and joints shall generally comply with SABS 956 – 1976 as amended.
- 4.30.10.4 Piping handling and installation shall generally be in accordance with Code of Practice SABS 0112 – 1992 as amended.
- 4.30.10.5 Only pipes and fittings bearing the SABS mark will be acceptable.
- 4.30.10.6 All horizontal pipework shall be adequately supported at intervals not exceeding those given in the table below which applies for ambient and water temperatures not exceeding 35°C. For higher temperatures continuous support shall be provided.

Nominal pipe diameter (mm)

10	1,25	20	25	30	40	50	60	75	100	150	200
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Maximum distance between supports (m)

0,25	0,30	0,30	0,35	0,35	0,45	0,45	0,50	0,60	0,90	1,0	1,0
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It is essential that where metal holder bats or other types of support are used that all rough edges that may damage the pipe surfaces are removed prior to installation. Pipes must be free to slide axially in the pipe supports to accommodate expansion and contraction.

Where pipes pass through walls or floors, suitable non-metallic sleeves must be provided to allow freedom of axial movement. Unistrut pipe supports and hangers shall be used throughout unless otherwise indicated on the drawings or in the specification. Pipe support hangers and "U-bolts", shall in all cases be provided with locknuts, which shall be securely locked. All brackets and pipe clamps shall be suitably galvanised, hot dipped to SABS 763 – 1977.

For vertical piping the above spacing may be doubled.

Expansion loops or telescopic expansion units shall be fitted in straight runs of pipe at intervals of not more than 50 meters, Pipes must be suitably anchored at appropriate places to ensure that expansion takes place in the desired direction so that it can be correctly taken up by the expansion devices, Anchors must be so designed as to render damage to or crushing of the pipe impossible.

Installation of expansion units on site must be done with due regard to the season and average ambient temperature prevailing when assembly takes place.

4.30.11 Testing of Piping Installations

- 4.30.11.1 Testing of the installation is to be carried out by the Contractor at his own expense in the presence of the Department's Representative. The following actions shall be carried out:
- After the flushing and cleaning of the pipelines, all lines shall be completely filled with cold water and bled of all air.
 - The pipe system shall then be subjected to a test pressure of 1,5 times the working pressure by means of a test pump. This pressure shall be maintained for a minimum of 60 minutes.
 - Any leaks apparent during the test shall be made good and the test repeated until no further leaks exist.
 - Items not capable of withstanding this test pressure shall be isolated from the pipe system.

4.31.0 INSTALLATION OF PIPEWORK AND DUCTWORK

- 4.31.1 Pipework and ductwork shall be installed in accordance with the service drawings issued with the Supplementary Specification.
- 4.31.2 The tender drawings are schematic and do not purport to show exact positions of pipes or ducts or specific details of construction of the latter. All final dimensions must be checked on site before preparation of manufacturing drawings and the fabrication of ducting and piping.
- 4.31.3 Where beams, stanchions or other obstructions interfere with the straight running of pipes or ducts, suitable offsets shall be provided or alternatively changes in the section of the particular duct made, all in accordance with good engineering practice.
- 4.31.4 Sufficient offsets or alternatively expansion bellows shall be allowed in piping installations to allow for expansion and contraction.
- 4.31.5 It is required that tenderers make themselves conversant with all the drawings of the particular building in order to determine the number of such offsets or changes in section and the positions in which they will be required.

Due allowance shall be made in the tender price for such offsets and changes required.

A complete set of drawings of the building may be inspected at the office of the Regional Representative of the Department.

4.32.0 PUMPS

- 4.32.1 Pumps shall be of the centrifugal type with non-overloading characteristics and volute casings.
- Pumps shall be selected for the maximum possible efficiency at the required duty point.
- 4.32.2 Pumps requiring an input power of less than 4,0 kW may be end suction pumps, close coupled to flange mounted motors.
- 4.32.3 Pumps requiring an input power of more than 4,0 kW may be end suction or horizontally split casing pumps mounted on a common baseplate with the drive motor with their shafts coupled with an approved flexible coupling.
- 4.32.4 Unless otherwise specified in the Supplementary Specification pump speed shall not exceed 1 500 r/min.
- No pump shall be operated at a speed exceeding the maximum recommended by the manufacturer.
- 4.32.5 Pumps shall be selected to handle the specified water flow quantities at the required total system resistance.
- Pump pressure and flow characteristics shall be selected to match the total system requirements under all control conditions.
- 4.32.6 The Contractor shall ensure that the minimum Net Positive Suction Head as required by the pump manufacturer is maintained throughout the required operating pressure and flow range at the pumped fluid temperature.
- 4.32.7 Renewable casing wearing rings shall be fitted on all pumps with discharge diameters of 80mm and larger and with delivery pressures in excess of 175 kPa. Wearing rings shall be manufactured of bronze, chromium steel, nickel steel or an alloy suitable for the particular application.

- 4.32.8 Impellers shall be manufactured of bronze and shall be statically and dynamically balanced. Impellers of pumps having 40mm diameter and larger discharge connections, shall be fully enclosed and hydraulically balanced.
- 4.32.9 Pumps shall be provided with mechanical seals matching the duty, fluid and temperature requirements.
- 4.32.10 Pump casing design pressure shall match the total system working pressure or be 1,5 times the discharge pressure, whichever is the greater.
- Pump casings shall be of close-grained cast iron.
- 4.32.11 Suction and discharge connections shall be flanged with machined flanges corresponding to the pressure rating of the casing.
- 4.32.12 Bearings shall be grease lubricated ball and roller bearings selected for long duty life and to accommodate radial and axial loads.
- Grease gun lubrication shall be provided. The grease gun nipples shall be of an approved type and shall comply with BS 1486 and be of the hexagonal "hookon" type 11 or 21.
- 4.32.13 A galvanised sheet metal drip tray with drain connection shall be provided underneath each pump. Drain connections shall be piped to the nearest drain or gully.
- In coastal applications the driptray shall be of stainless steel.
- 4.32.14 Pump shafts shall be of EN57 stainless steel with stainless steel mechanical seal holders.
- 4.32.15 Pumps with stuffing box type shaft seals will only be considered if:
- The shaft is fitted with a replaceable stainless steel wearing sleeve,
 - A lantern ring is fitted,
 - A minimum of 4 standard packing rings can be fitted, and
 - Bronze thrust bushes are provided.
- 4.32.16 Drive motors shall be selected with at least 15% more power than the maximum pump requirements.
- 4.32.17 Pumps for water temperatures in excess of 90°C shall be provided with water-cooled bearings and seals.
- 4.32.18 All pump casings shall be provided with plugged drain and vent trappings.
- In addition pumps of 4,0 kW or larger input power shall be provided with plugged tappings for suction and delivery pressure gauges and a filling point.
- Tappings or internal drilling shall be provided for gland and bearing cooling water where necessary.
- 4.32.19 Pumps of design different from that specified above offered as integral parts of factory made equipment, will also be considered.

4.33.0 HUMIDIFIERS

4.33.1 Humidifiers shall be of the electrical electrode steam generating self-contained type with electronic controls.

Pan type or water spray type humidifiers will not be acceptable unless specifically called for in the Supplementary Specification.

4.33.2 Humidifiers shall be suitable for the water of the particular application with controls fully adjustable to match local requirements.

4.33.3 Generator bottles shall be fully replaceable on electrode wear. Units with openable, cleanable generator bottles and replaceable electrodes are preferred.

4.33.4 Steam injection shall not be in the air handler or upstream of the fan, filters, coils, etc., but downstream thereof. Steam distribution shall be over the full width of the duct with stainless steel distribution pipework. The pipework shall be so arranged that condensate is returned to the humidifier and does not end up in the duct.

4.33.5 The humidifier shall be selected for discharging the steam directly into the supply air duct against the operating static pressure. Steam shall be discharged as uniformly as possible into the air stream and the installation of the distribution manifold shall comply with the following:-

- a) The manifold shall be installed across the widest dimension of the duct in the centre.
- b) The manifold length shall not be less than 85% of the widest duct dimension.
- c) Two or more distribution manifolds shall be installed where the duct dimension exceeds 800mm.
- d) Where the distribution manifold may restrict the airflow in small ducts, the duct shall be enlarged at the point where the manifold must be installed.
- e) A distance of at least 3m shall be provided between the distribution manifold and any downstream temperature controller.
- f) A distance of at least 2m shall be provided between the distribution manifold and the first air outlet in the duct system.
- g) The distribution manifold shall not be installed vertically downward from the humidifier.

4.33.6 A high limit duct humidity controller shall be provided to limit the output capacity or stop the humidifier when the humidity in the duct exceeds 90%. The humidity-sensing element shall be not less than 3m downstream of the distribution manifold.

4.33.7 The maximum output capacity of the humidifier shall be manually adjustable and limited to correspond with the specified maximum demand of the system.

4.33.8 Humidifiers shall be inter-locked with the relevant supply air fans to shut water and electrical supplies off when the particular fan is not running.

4.33.9 Humidifiers shall be connected to the available water supply point. A suitable stop valve shall be provided in the supply water connection. Wastewater from the humidifiers shall be discharged into an open tundish and connected with a 32mm nominal pipe to the nearest drain. Supply and drain piping shall be of galvanised steel.

4.33.10 Humidifiers shall be equipped with fail safe safety controls for low water level or interrupted water supplies.

4.33.11 The humidifier shall be electronically controlled with a minimum of three steps, proportional control is however preferred.

The humidifier shall be complete with its own integral controls in a lockable panel.

The electrodes must have built-in overcurrent protection and the unit must have an adjustable automatic control for draining and filling.

4.33.12 Humidifying control shall be through the use of a controlled water level.

4.33.13 A high-level safety switch shall be provided to prevent overflow.

4.33.14 Each humidifier shall be provided with an ammeter or demand indicator, indicating LED lights for water level and drain cycle and an alarm for the cylinder to be changed.

4.33.15 Access to all components for servicing shall be arranged by panel casing design and construction.

4.34.0 WATER TREATMENT

4.34.1 General

4.34.1.1 Water treatment shall be provided for all cooling towers, open and closed circuit type as well as evaporative condensers.

4.34.1.2 Water treatment and water quality control shall be provided to match the specific application and local site and water conditions.

4.34.1.3 Water treatment for evaporative cooling units shall be provided only where specifically called for in the Supplementary Specification.

4.34.2 Water Softener

4.34.2.1 Water softeners shall be installed in the make-up lines to evaporative condensers and cooling towers.

4.34.2.2 Where capacities are not specifically specified the softener shall have sufficient capacity to ensure that the make-up demand is met under all operating conditions and that the softener will be capable of operating for at least 48 hours without regeneration.

4.34.2.3 The softener shall function automatically and must be of the base exchange type, manufactured from corrosion resistant materials.

4.34.2.4 The softener and dosing plant (where specified) shall be of the same manufacture and provided by the same supplier.

4.34.2.5 The resin bed exchange rate must not be higher than 45kg/m^3 during regeneration and the softened water shall not contain more than 10mg/litre of total dissolved solids as CaCO_3 .

4.34.2.6 The softener shall be complete with a Kent or equal flow recording meter, control wiring, brine tank etc. and a bypass valve arrangement.

4.34.2.7 Each water softener shall be equipped with a time control mechanism to automatically control the time lapse between regeneration cycles for any period between 24 hours and 7 days. Alternatively the regeneration cycle may be controlled volumetrically by means of a meter in the soft water outlet pipeline.

4.34.2.8 Each softener shall be equipped with an automatic diaphragm valve, salt solution tank, salt storage compartment, salt solution ball valve and the necessary connections for draw-off and refilling of salt solutions.

- 4.34.2.9 The brine tank shall hold at least one week's brine for summer conditions, and shall be manufactured from PVC, Polypropylene or similar material.
- 4.34.2.10 Drainage pipework must be piped to the nearest drainpipe.
- 4.34.2.11 The softener shall be installed to match the existing site water pressure. If the water pressure is too high a pressure-reducing valve similar and equal to Glenfield & Kennedy or approved shall be installed. If the water pressure is too low a booster pump of sufficient capacity shall be installed.
- 4.34.3 Water Dosing Plant
- 4.34.3.1 Unless otherwise specified cooling tower/condenser water circuits shall be provided with automatic dosing plant including bleed control.
- 4.34.3.2 Where capacities are not specified the dosing plant shall have sufficient capacity for the application and local water quality.
- 4.34.3.3 Each evaporative condenser or cooling tower circuit must be provided with it's own independent dosing plant and bleed control.
- The dosing system must be complete with all necessary chemicals, controls, valves and appliances.
- 4.34.3.4 The system shall comprise an automatic bleed-off valve controlled by an electronic measuring cell from the water conductivity and automatic measuring type dosing pump/s. The electronic measuring cell must continually measure the water conductivity and control the bleed-off valve and dosing pump/s accordingly.
- 4.34.3.5 The pre-set values of the water conductivity (TDS) must be adjustable. The TDS shall be controlled in the range of 600-800mg/ litre.
- 4.34.3.6 The water treatment shall ensure that:
- a) Scale forming and corrosion are prevented,
 - b) Algae and microbiological growth is controlled,
 - c) Sediment is controlled with low water consumption.
- 4.34.3.7 Chemicals provided shall be well known products, and approved dilution tanks as reservoirs for the metering pumps must be provided.
- 4.34.3.8 Sufficient chemicals and salt must be provided at first hand over for three months use.
- 4.34.3.9 When the plant is in effective operation, water samples shall be drawn after the softener and from the condenser sump. The samples must be analysed by a recognised laboratory suitably equipped and the report submitted to the Regional Office.
- 4.34.3.10 Service calls with water analysis and recognised corrosion tests must be carried out every three months during the maintenance period and reports sent to the Regional Office.
- 4.34.3.11 The chemicals used shall be stable over at least a 12-month period and shall not break down and cause clogging of the dosing apparatus.
- 4.34.3.12 Isolating valves shall be provided to allow all components of the water treatment plant to be removed for maintenance without affecting the operating of the cooling plant.
- 4.34.3.13 The water treatment plant shall be electrically interconnected with the recirculating water pump so that it cannot operate unless the pump is running.

4.35.0 FIRE DAMPERS

- 4.35.1 Combination fire/smoke control dampers complying with SABS 193 and NFPA 90A are required in the positions indicated on the main drawings.
- 4.35.2 The dampers shall be UL (underwriters Laboratories) or SABS certified with proven low leakage in the closed position.
- 4.35.3 Dampers shall be actuated by fusible link, electrical solenoid or pneumatic means as specified in the Supplementary Specification.
- 4.35.4 Fire dampers shall be flanged both sides and access panels shall be provided in the ducting at each fire damper on the upstream side.
- 4.35.5 Each fire damper shall be clearly marked as per clause 4 of SABS 193.
- 4.35.6 Fire dampers shall have at least a 2-hour resistance rating when tested in accordance with SABS 193.
- 4.35.7 Insulating fire dampers shall be fitted where indicated on the drawings.
- 4.35.8 The open or closed status of the damper shall be clearly indicated outside the casing for inspection purposes.
- 4.35.9 Dampers shall be sized so that the nominal free air area when in the open position is not less than the connected duct free air area.
- 4.35.10 Dampers shall be installed so as to form part of a continuous barrier to passage of fire when in a closed position. Where a fire damper cannot be fitted immediately adjacent to the firewall, the section of ducting between damper and wall shall be of at least the same metal thickness and fire rating as the damper casing.
- 4.35.11 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.
- 4.35.12 Suitable hand openings with tightly fitted covers shall be provided to make dampers accessible for inspection and maintenance.

4.36.0 DUCTWORK

4.36.1 Sheetmetal Ductwork

- 4.36.1.1 Sheetmetal ductwork shall be manufactured in accordance with SABS 1238 : 1979 as amended and installed, balanced and tested as set out in SABS 0173 : 1980, as amended.
- 4.36.1.2 Ductwork layouts, dimensions etc. shall be as indicated on the drawings issued with the Supplementary Specification.
- 4.36.1.3 Where changes in duct sizes indicated are necessitated on site, duct sizes shall be determined using equivalent diameters (hydraulic diameter) and not cross-sectional area.
- 4.36.1.4 Aspect ratios in excess of 4:1 shall be avoided in rectangular ductwork. Internal duct dimensions of less than 200mm in rectangular ducting will not be acceptable in low and medium velocity ductwork.
- 4.36.1.5 Adjustable opposed blade dampers, duct splitters and turning vanes shall be provided where shown on the drawings.
- 4.36.1.6 Unless otherwise specified ductwork shall be manufactured of galvanised sheet steel.
- 4.36.1.7 Ductwork shall be painted as specified.

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- 4.36.1.8 Flexible joints shall be provided between all fans, airhandlers, vibration inducing equipment, etc. and ducting.

Flexible joints exposed to weather shall be provided with protecting galvanised sheet steel cover strips.

Flexible connections shall be made of fireproof fabric reinforced airtight material attached both sides with approved galvanised steel collars or frames.

- 4.36.1.9 Ductwork connected to equipment such as cooling towers, evaporative condensers, plenum chambers etc. shall be provided with flanged removable sections to allow for removal and access to eliminators etc.

4.36.2 Flexible Ductwork

- 4.36.2.1 Where indicated on the main drawings ductwork shall be connected to mixing boxes and integrally mounted ceiling diffusers by means of flexible ducting.

- 4.36.2.2 Flexible ducting shall consist of aluminium foil faced glass fibre fabric mechanically interlocked by a corrosion resistant metal spiral helix on the outside of the fabric.

- 4.36.2.3 Flexible ducting shall comply with local fire codes, NFPA Bulletin 90A and SABS 0400 fire resistance requirements.

- 4.36.2.4 Flexible ducts connected to diffusers or mixing boxes shall, unless otherwise shown or approved, not exceed 1,5m in length nor have more than the equivalent of two 90-degree bends. Bends shall be of the maximum possible radius without flattening or distorting the flexible ducting.

- 4.36.2.5 Flexible ducting shall be supported with sufficient and correct brackets that will ensure maintenance of shape.

- 4.36.2.6 Flexible ducting shall be externally insulated where insulation of ductwork is called for in the Supplementary Specification.

4.36.3 PVC Ductwork

- 4.36.3.1 PVC ductwork where called for in the Supplementary Specification shall be of unplasticised polyvinyl chloride (uPVC) manufactured and installed in accordance with specification DW151 "Specification for Plastics Ductwork" of the "Heating and Ventilating Contractor's Association" and/or SMACNA - "Thermoplastic Duct Construction Manual".

- 4.36.3.2 The class of ducting used shall be as specified.

- 4.36.3.3 Proper provision shall be made for expansion and contraction of the ductwork.

- 4.36.3.4 Flexible connections shall be made of plasticised polyvinyl chloride (PVC).

- 4.36.3.5 Duct joints shall be welded flanges or male/female socket type welded all-round.

All welded joints and seams shall be tested by high frequency spark test at 40kV.

4.36.4 Testing

- 4.36.4.1 Unless otherwise specified the total ductwork installation shall be tested for leakage as per SABS 0173.

- 4.36.4.2 Leakage rates in excess of 5% of the required air flow quantity in any section of ductwork or in excess of the SABS permissible leakage, whichever is the smaller, will not be accepted.

4.37.0 AIR OUTLETS AND DAMPERS

4.37.1 Grilles

4.37.1.1 Supply and return air grilles shall be provided as indicated on the drawings.

Each grille shall be selected in accordance with the manufacturer's recommendations to be capable of passing the specified air quantity without creating excessive resistance, noise or local draughts.

4.37.1.2 Grilles shall be manufactured of stamped, extruded or rolled aluminium or steel sections, finished as specified and mounted in a neat frame.

4.37.1.2 Supply air grilles shall be provided with double deflection aerofoil vanes adjustable from the front of the grille.

Vanes shall be spaced at not more than 20mm centres.

4.37.1.4 Exhaust and return air grilles in the same installation shall be similar in general appearance and construction to the supply air grilles but with a single set of fixed vanes.

4.37.1.5 Supply air grilles shall be provided with opposed blade volume control dampers adjustable from the front of the grille.

Return air grilles shall be provided with opposed blade dampers for volume control only where called for on the drawings. Dampers shall be adjustable from the front of the grille.

4.37.1.6 Grilles shall in all cases be selected with free air passage areas not less than that indicated on the drawings.

4.37.2 Weather Louvres

4.37.2.1 Weather louvres shall be manufactured of extruded aluminium sections or ferrous metal hot dip galvanised after manufacture, as specified.

4.37.2.2 Weather louvres shall be constructed with drip edges to blades and rigid frame to enable building in.

4.37.2.3 Weather louvres shall be finished in natural anodised aluminium, powder coated or painted as specified.

4.37.2.4 Weather louvres shall be watertight even with nominal air velocity up to 3,0m/s.

4.37.2.5 Weather louvres shall be fitted with 12mm opening size galvanised expanded metal or wire mesh screen.

4.37.2.6 Top and bottom blades shall be fitted flush with the frame and smooth without grooves, channels or recess where dirt or water can collect.

4.37.3 Diffusers

4.37.3.1 Diffusers shall be square, round or rectangular with faceplates matching the ceiling grid as specified, manufactured from pressed or spun steel or aluminium sheet metal.

4.37.3.2 Each diffuser shall be selected in accordance with the manufacturer's recommendations to be capable of passing the specified air quantity without creating excessive resistance, noise or local draughts.

4.37.3.3 Each diffuser shall be provided with an opposed blade volume control damper. Dampers shall be selected and installed so as not to disturb the supply air distribution pattern or induction ratio of the diffuser.

4.37.3.4 Diffuser cores shall be removable for cleaning and access purposes.

4.37.4 Variable Volume Outlets

4.37.4.1 Variable volume outlets with controls and reheaters shall be provided where indicated on the drawings.

4.37.4.2 Only well-catalogued and proven products will be considered.

4.37.4.3 Minimum air volume shall be factory set and site checked for each outlet.

4.37.4.4 Outlets shall be selected and installed to ensure that no dumping or coning of supply air streams occur, particularly at low air flow rates.

4.37.4.5 Variable volume control shall be achieved with pneumatic or electric drives as specified. Low noise levels during operation is essential.

4.37.4.6 Reheaters shall be protected against overheat and shall be switched with an adequately rated and reliable microswitch.

4.37.4.7 Easy access to all parts possibly requiring servicing or setting shall be provided.

4.37.5 Dampers

4.37.5.1 Dampers for positive volume control purposes shall be manual, pneumatic or electric actuator driven as specified and provided where indicated on the drawings.

4.37.5.2 Damper blades, links and damper frames shall be of rigid construction galvanised steel generally as per SABS 1238, and of the opposed blade type.

4.37.5.3 Manually adjusted dampers shall be provided with adjusting levers in accessible positions with provision for positive locking in any position from fully open to fully closed.

4.37.5.4 Dampers shall be of the link or gear type as specified.

4.37.5.5 Dampers creating unacceptable vibrations and noise levels will be rejected and will need to be replaced at the Contractor's expense.

4.38.0 INSULATION

4.38.1 General

4.38.1.1 Insulation shall in all instances be applied by specialist contractors and be of the highest standard. Any section not installed to the approval of the Department shall be re-done at the Contractor's expense.

4.38.1.2 Prior to insulation being fitted, all pressure testing shall be completed satisfactorily.

4.38.1.3 Insulation, cladding and vapour barriers shall be painted as specified.

4.38.1.4 All items of plant likely to operate at temperatures below the surrounding ambient dew point shall be insulated and provided with a vapour barrier.

4.38.2 Ductwork

4.38.2.1 All air ducts carrying heated or cooled air, except where specifically excluded in the Supplementary Specification shall be thermally insulated.

- 4.38.2.2 Ductwork shall be internally or externally insulated as specified. If no mention is made in the Supplementary Specification, internal insulation shall be offered unless circular ducts are indicated on the drawings. These shall be externally insulated in all instances.
- 4.38.2.3 Ducts for ventilating plants supplying heating only shall be insulated except within the heated space.
- 4.38.2.4 Internal duct insulation shall consist of not less than 25mm thick neoprene or flexible fabric faced fibreglass which shall be secured to the duct by means of suitable adhesive in addition to metal fasteners similar or equal to Gripnail or Duradyne Weldpins, generally in accordance with SABS 1238 - 1979. Flexible fabric face insulation shall be similar or equal to Eurosonic.
- 4.38.2.5 External insulation shall generally be in accordance with SABS 0173 - 1980.
- 4.38.2.6 Fibreglass density shall be a minimum of 24kg/m^3 for internal insulation and external insulation in unexposed areas. For external insulation in exposed areas such as plantrooms, service trenches and service ducts, the minimum density shall be 48kg/m^3 .

Thermal conductivity in both instances shall not exceed $0,037\text{ W/m}^{\circ}\text{K}$.

- 4.38.2.7 In unexposed areas such as roof spaces, etc., external insulation shall be protected with a neoprene or aluminium foil cover. These shall be strapped at intervals not exceeding 500mm with nylon straps and buckle clips or similar approved method.
- 4.38.2.8 All air conditioning ductwork externally insulated shall be provided with a continuous vapour barrier, sealed with adhesive aluminium tape or equal. The vapour barrier shall comply with the flammability requirements for sealing membranes as per SABS 1238 - 1979.
- 4.38.2.9 Particular care shall be taken with insulation at ductwork joints to ensure maximum possible insulation of duct surfaces, special reference shall be made to clauses 4.8.3 to 4.8.7 of SABS 1238.
- 4.38.2.10 External insulation in exposed areas shall comprise 40mm thick fibreglass to cover all flanges, joints, etc. It shall be externally clad with a galvanised sheetmetal skin over a vapour barrier and painted to specification.

Horizontal surfaces and joints in the sheet metal cladding shall be such that they shed water.

Alternatively, the outer metal skin may be substituted with 25mm mesh wire netting, stapled to the insulation and then covered with a 10mm layer of hard setting plaster trowelled to a smooth even finish. The plaster shall be coated with one coat liquid polymer such as "Foster Sealer" or "Decadex", followed by a reinforced fibreglass scrim, fixed with a suitable adhesive, and a second coat of liquid polymer. The duct shall then be painted as specified.

The method employed shall be as set out in the Supplementary Specification.

- 4.38.2.11 Flexible ducting shall be proprietary made complete with insulation at least 40mm thick fibreglass equivalent and an acceptable fire retardant outer layer.

Where flexible-ducting joins on to sheet metal ducting the joints shall be sealed with foil backed adhesive tape.

4.38.3 Insulation of Hot Water Piping and Fittings

- 4.38.3.1 All hot water piping shall be insulated with pre-formed insulation matching pipe size and specified thickness, painted and colour coded as specified.
- 4.38.3.2 The insulating materials shall comprise pre-formed glass fibre rigid or mineral wool sections of long fine fibres, bonded with a temperature resistant binder. The thermal conductivity shall not exceed $0,038\text{ W/m}^{\circ}\text{K}$, and the density shall not be less than 80kg/m^3 . The sections shall be rot-proof, odourless, non-hygrosopic and non-combustible.

Minimum thickness shall be in accordance with the table below:

Pipe diameter (mm)	15-25	32-50	65-80	100 and larger
Glass fibre insulation thickness (mm)	20	25	40	50

- 4.38.3.3 Insulation shall be held in position by aluminium, galvanised steel, stainless steel or nylon straps. These straps are to be located at butt joints between lengths of insulation and at 300mm centres over the length of the insulation.
- 4.38.3.4 Insulation to bends on unexposed pipework (e.g. in roofspaces etc.) may be formed from mitred and trimmed sections, cut to ensure that a good contact with the surface to be insulated is made, alternatively moulded trowelled insulation may be applied.
- 4.38.3.5 To ensure maximum continuity of insulation, adjoining sections shall be firmly butted together and sealed with a self-adhesive tape at least 50mm wide. At valves, fittings and pipeline equipment the insulation shall be taped together in a similar fashion. Open ends of rigid sections shall be sealed off with a suitable mastic.
- 4.38.3.6 All piping, hot water valves and fittings shall be clean, dry and free of grease, loose rust and scale before any insulation is applied.

Where specified piping shall be painted prior to application of insulation.

- 4.38.3.7 Where hangers and/or supports occur along the run of the insulated pipes, a segmental section of hardwood approximately 70mm long shall be inserted, the outer diameter being identical to that of the insulated pipe and the ends thereof butted to the insulation. The insulation finish shall be continued over the hardwood insert and the finish shall be protected by means of sheet metal hoops under the bracket, against movement of the pipe and/or hanger.

Alternatively for pipes of diameter 80mm or less the pipes may be supported over the insulation with approved non-crushing hoop type hangers. Supports compressing the insulation will not be accepted.

- 4.38.3.8 All pipes exposed to the weather or where the insulation is likely to be damaged or where visible inside buildings and plantrooms, are to be provided with a covering of galvanised sheetmetal over the insulation, adequately secured. Sheetmetal thickness shall be not less than 0,5mm for pipe sizes up to 100mm diameter and not less than 0,8mm for larger pipe sizes.

The sheetmetal covering shall be held in position with 10mm wide stainless steel metal bands spaced to ensure a neat and firm finish at intervals not exceeding 500mm. Longitudinal overlap joints shall be arranged to be in one line at 10 o'clock or 2 o'clock and to be water shedding.

- 4.38.3.9 Flanged joints shall be separately covered by pre-formed insulation flange boxes (muff covers) held in position by removable metal bands and finished similarly to the lagging on piping.

The flange boxes shall be capable of removal without damage to any other portion of the insulation.

- 4.38.3.10 Hot water pipes exposed to the weather shall be insulated and clad in such a manner that no moisture or rainwater may penetrate the insulation.

Support brackets, hangers, etc. shall be external to the insulation and cladding and no cut-outs will be permitted.

- 4.38.3.11 All bends on indoor pipework are to be insulated with moulded plastic lagging (see below) of same or better insulation property than the sectional insulation, trowelled to a smooth finish to the same diameter as the sectional insulation and then neatly bound with an approved tape and painted, or alternatively insulated with mitred sections.

- 4.38.3.11 Lobster back weatherproof galvanised sheet steel bends with segmented glass fibre lagging must be used where pipework is exposed to the weather.

Alternatively, bends may be insulated with plastered hard setting moulded plastic asbestos lagging strengthened with galvanised wire netting and trowelled to a smooth finish of the same diameter as the sheet metal covering. The insulation shall be finished with 4 coats silicated soda and then neatly bound with an approved tape and painted as specified.

- 4.38.3.13 Pipes to be chased into brickwork shall be wrapped with suitable mineral fibre or glass fibre tape approximately 6mm thick.
- 4.38.3.14 Pipe insulation not covered with sheetmetal cladding shall be covered with canvas having at least a 50mm overlap at joints. Overlaps shall be sealed down with a suitable adhesive.
- 4.38.3.15 Hot water valves and fittings shall be insulated similarly.
- 4.38.3.16 Unless otherwise specified in the Supplementary Specification expanded high density polyethylene material may only be used where the pipework is entirely under cover and protected, e.g. roof spaces, etc. and only on pipes up to 50mm diameter. It shall not be used in plantrooms or where at risk of physical damage.

The material shall be of expanded cross-linked polyethylene, with SABS certified self-extinguishing properties similar and equal to "Thermafex" type QE40.

The thermal conductivity of the material shall not exceed 0,038 W/m²K. Nominal insulation thickness shall be 20mm.

Straight sections shall be applied in 2 metre lengths where possible and closed by means of the zipper. Tees and elbows shall be insulated employing pre-formed sections. Alternatively mitred cut sections shall be employed, taped together with HDPE tape to ensure a sealed fit. Joints in straight lengths or between fittings and straight lengths shall be taped for a minimum of 40mm on either side of the joint, employing HDPE tape.

4.38.4 Insulation of Chilled Water Piping and Fittings

- 4.38.4.1 Chilled water and refrigerant suction piping shall generally be insulated as set out above with the specified material, material thickness and vapour barrier, painted and colour coded as specified.
- 4.38.4.2 All chilled water and refrigerant suction piping shall be insulated in a workmanlike manner to modern practice.
- 4.38.4.3 Insulation shall be sectional resin bonded glass fibre with density not less than 95kg/m³. The insulation thickness shall be not less than 25mm for pipe sizes up to 40mm diameter and not less than 40mm thick for larger diameter pipes and shall be provided with a factory applied canvas finish.
- 4.38.4.4 All circumferential joints to the insulation shall receive one application of "Foster Foamseal 30-45" or equivalent to the full thickness of the insulation during erection to prevent lateral penetration of moisture along the pipe when in service.

At all points where the vapour barrier is broken due to cutouts, the insulation shall be sealed as above, during erection.

- 4.38.4.5 Bends shall be insulated with 12mm or 27mm thick asbestos plastic insulation compound, covered by a 13mm thick layer of asbestos hard setting compound, trowelled to a neat smooth and symmetrical finish. Two coats of Decadex or equal shall be applied as vapour barrier prior to painting as specified.
- 4.38.4.6 Concealed and exposed chilled water piping and refrigerant suction lines, valves and fittings, shall be covered over the insulation with an aluminium foil/kraft paper vapour barrier with 50mm overlap at joints, sealed with a suitable adhesive, with no further cladding.

4.38.4.7 Concealed piping and fittings shall be vapour sealed over the insulation without any further cladding, but colour coded as specified.

4.38.4.8 Exposed chilled water piping and refrigerant suction lines, in plantrooms, and in areas where pipes are likely to be damaged or where exposed to the weather, shall be covered over the vapour barrier specified above with a 10mm thick layer of W.R. 700 Armour plaster or equal, trowelled to a smooth and even finish. When dry the plastered surface shall be painted as specified. Valves and fittings shall be plastered or wrapped in non-sweating "Denso" or equal tape where plaster is not possible and where diameters are 32mm or less.

As an alternative to the plaster finish 0,9mm galvanised sheet metal or 1mm thick aluminium sheeting as a cladding may be provided over the vapour barrier specified. Valves and fittings shall be plastered as specified above. Galvanised sheet metal shall be painted as specified. No painting is required on aluminium coverings, except colour coding as specified.

4.38.4.9 As an alternative vapour barrier to the aluminium foil/kraft paper vapour barrier specified above the plaster cover to the insulation shall be painted when dry with Decadex LPL sealer or equal followed by two high build brush coats of Decadex Firecheck Copolymer liquid plastic or equal. The surface shall be reinforced by embedding a layer of open weave fibre-glass membrane in the Firecheck.

4.38.4.10 Refrigerant suction lines may alternatively be insulated by means of "Thermafex" Type 40 QE cross-linked polyethylene foam tube insulation, neoprene rubber foam with quick zip fastener, or equal. The insulation material shall meet the following minimum requirements:

Temperature range	:	-80°C to +120m°C
Thermal conductivity	:	0,038 W/m°K at 0°C
Thickness	:	10mm
Density	:	35kg/m ³
Odour properties	:	Neutral
Cellular structure	:	Totally closed
Fire properties	:	Self-extinguishing to SABS

The insulation shall be applied to form a continuous and homogeneous vapour barrier over bends, supports, etc.

Where these pipes are run in areas exposed to sunlight, they shall be installed inside suitable galvanised mild steel trunking or other approved method of covering.

4.38.4.11 When completed the installation shall ensure a complete vapour barrier and any signs of sweating or dripping shall cause the installation to be rejected.

4.38.5 Steam Piping

4.38.5.1 Steam piping shall generally be insulated as specified for hot water systems.

4.38.5.2 Pre-formed fibreglass or mineral wool sections of density not less than 96kg shall be used.

4.38.5.3 Thickness shall be as set out below:

Pipe diameter (mm)	15	20	25	32	40	50	65	80 and larger
Insulation thickness (mm)	25	25	25	40	40	40	40	50

4.38.5.4 Surface temperatures shall not exceed 40°C when in use. Unless otherwise specified in the Supplementary Specification, condensate pipes shall not be insulated.

4.38.6 Shell and Tube Water Coolers

- 4.38.6.1 These shall be insulated with 25mm thickness fibreglass slabs fastened to the cooler by means of mechanical fasteners. Covering shall be as for exposed chilled water piping with a homogeneous vapour barrier.
- 4.38.6.2 Cutouts and penetrations shall be sealed with a vapour barrier.
- 4.38.6.3 Factory insulated equipment shall be acceptable provided this is to the approval of the Department.

4.39.0 AUTOMATIC CONTROL SYSTEMS

4.39.1 General

- 4.39.1.1 Unless otherwise specified in the Supplementary Specification controls shall be electric or electronic or a combination thereof.

Controls shall be analogue or direct digital as specified in the Supplementary Specification.

- 4.39.1.2 The performance of sensors, controllers and outputs shall be such that stability is ensured under all operating conditions.
- 4.39.1.3 Provision shall be made on controllers to enable adjusting control loop stability such as adjustable proportional bands, adjustable reset rates etc.
- 4.39.1.4 Closed loop control systems are required generally with one or more of the following control actions;

- a) Two-position action, maximum/minimum or on/off.

The differential shall be adjustable.

- a) Floating action with the controller moving the controlled device to its open or closed position with a neutral zone between the two positions allowing the controlled device to stop at any position whenever the controlled variable is within the differential of the controller.

Whenever the controlled variable gets outside the differential of the controller, the controller shall move the controlled device in the proper direction.

- b) Proportional action where the controlled device is positioned proportionally in response to slight changes in the controlled variable.

The throttling range shall be adjustable to suit the application. Controllers with excessive droop or steady-state error will be rejected.

- d) Proportional plus integral control and proportional-integral-derivative controls shall be provided on sensitive installations and where specified in the Supplementary Specification.

4.39.2 Controllers

- 4.39.2.1 Controllers shall be designed for minimum time lag around the control loop.
- 4.39.2.2 Adjustments shall be made to the various control modes of each controller to obtain maximum regulation quality. Systematic trial methods or adjustment shall be avoided as far as possible. Recommendations of the controller manufacturer shall be carefully followed or alternatively adjustments shall be made based on the ultimate sensitivity calculated method.
- 4.39.2.3 Non-adjustable controllers or controllers with inadequate adjustment facility will not be accepted.

- 4.39.2.4 Provision shall be made to prevent noise signal disturbances in the control loop. Where noise cannot be eliminated completely by means of filtering or averaging noise out of the signal or by shielding control wires against stray voltages, etc., proportional plus reset controllers shall be used.
- 4.39.2.5 Controllers and all control items shall be housed in a separate cubicle in the electrical control panel/switchboard.
- 4.39.2.6 Controllers shall be of the indicating type with the value of the controlled variable clearly indicated on a suitable scale.
- 4.39.2.7 Direct digital controllers shall make use of a microprocessor or computer to implement control algorithms on one or more multiple control loops as required.

Pre-programmed control routines shall be stored in permanent programmable read only memory unless otherwise specified.

User programmable controllers shall only be provided where specified in the Supplementary Specification.

- 4.39.2.8 Where intelligent programmable controllers are specified it shall comply with the following as a minimum;
 - ? flexible direct digital control
 - ? touch screen with pre-programmed control applications ensuring ease of commissioning and operation
 - ? simple interrogation and setting of control parameters through the touch screen with graphical LCD display
 - ? real-time feature enabling continued operation even after a power failure
 - ? graphics software package with easily programmed special applications
 - ? proportional plus integral plus derivative control actions that can be individually set to match application
 - ? full monitoring and logged data capacity combined with graphical display of stored data
 - ? providing full alarm monitoring
 - ? interfacing with building management system must be possible with standard interface facility for remote computer configuration

4.39.3 Control of Single Centrifugal Water Chillers

- 4.39.3.1 Unitary equipment such as centrifugal chillers shall be provided with it's own built-in control and safety systems, generally as supplied standard by the manufacturer.
- 4.39.3.2 Interlocks and interfacing with the system shall be provided as specified in the Supplementary Specification.
- 4.39.3.3 The following interlocks and safety controls shall however be provided as a minimum;
 - ? anti-freeze protection to evaporator
 - ? the compressor shall not run unless the chilled water pump, condenser water pump and cooling tower fans are running (water cooled)
 - ? the capacity regulating vanes shall remain closed until the motor is connected across the full line voltage
 - ? the capacity regulating vanes shall close, or at least in the limit, remain constant when the motor load exceeds full load. The motor overload control shall override the chilled water temperature control.

- 4.39.3.4 For off-season operation a manual demand-limit-control shall be fitted. This demand-limit-control shall override the automatic capacity control to limit current drawn by the chiller during off-season operation. This control shall be able to limit the motor current to a maximum of 50% of full load current.
- 4.39.3.5 Leaving chilled water temperature shall be controlled to within $\pm 1^{\circ}\text{C}$ of the specified temperature by suction vane positioning in the compressor intake.
- 4.39.3.6 On starting of the chilled water pump, local manually or remote automatically all chiller controls shall be energised and function automatically.
- 4.39.3.7 When cooling of the chilled water is required, the condenser water pump, cooling tower fans (or condenser fans if air-cooled) and compressor shall start automatically and in sequence.
- 4.39.3.8 All centrifugal chillers shall be provided with microprocessor unit control modules with serial interface for remote monitoring and/or control by a building management system.

Demand limiting control shall be possible from the remote building management system.

The microprocessor unit control modules shall generally provide the following as a minimum;

- ? liquid crystal display with LED back lighting
- ? entry section to enter setpoint changes, cancel inputs, set day and time
- ? print section with standard printer port to permit hard copy printouts, with separate printer, of operating data for unit and history of fault shutdowns. (Printer by others)
- ? program section to program functions such as cut-outs, unloading, anti-recycle timer, etc.

The following displays are required;

- ? - water temperature in/out
- ? - cut out settings;
 - water temperature
 - ambient temperature
 - suction temperature
- ? pressures for each system;
 - suction
 - delivery
- ? anti-recycle timer setting for each compressor
- ? day, date and time
- ? daily stop/start times
- ? automatic or manual lead/lag control (where applicable)
- ? fault shut downs
- ? number of unloading step
- ? percent full load motor current

4.39.4 Control of Reciprocating Water Chillers

- 4.39.4.1 On starting of the chilled water pump, local manually or remote automatically all chiller controls shall be energised and function automatically.
- 4.39.4.2 Leaving chilled water temperature shall be controlled to within $\pm 1^{\circ}\text{C}$ of the specified temperature by unloading of cylinders and/or switching compressors on or off as necessary.
- 4.39.4.3 Compressors shall be automatically stopped/started and loaded or unloaded in steps and in sequence in accordance with the return chilled water temperature.
- 4.39.4.4 Interlocks and interfacing with the system shall be provided as specified in the Supplementary Specification.
- 4.39.4.5 The following interlocks and safety controls shall however be provided as a minimum;
 - ? the compressor shall not run unless the chilled water pump, condenser water pump and cooling tower fans are running (water cooled)
 - ? anti-freeze protection to evaporator
 - ? compressors shall always start unloaded.
- 4.39.4.6 All chillers larger than 150kW cooling capacity (and where specified in the Supplementary Specification) shall be provided with microprocessor unit control modules with serial interface for remote monitoring and/or control by a building management system.

Clause 4.39.3.8 above shall generally apply.

- 4.39.4.7 On multiple circuit chillers compressor starting/stopping shall be in sequence and on units larger than 100kW cooling capacity (and where specified in the Supplementary Specification) automatic lead/lag control for equalising compressor running hours is required.

4.39.5 Control of Screw Compressor Water Chillers

- 4.39.5.1 Screw compressor water chillers shall generally be controlled as specified for centrifugal water chillers.
- 4.39.5.2 Clause 4.39.3.8 above shall generally apply.

4.39.6 Control of Airhandling Unit Equipped with Chilled Water Coil and Hot Water Coil or Electric Elements for Heating

- 4.39.6.1 Both heating and cooling shall be controlled by a single room or return air sensor and controller as specified.
- 4.39.6.2 A control range of approximately $15^{\circ}\text{C} - 30^{\circ}\text{C}$ is required with a dead zone of approximately $0,5^{\circ}\text{C}$ between cooling off and heating on and vice versa.
- 4.39.6.3 The controls shall maintain the specified temperature $\pm 1^{\circ}\text{C}$ by controlling the control valves on the cooling and heating coils. (or heating elements)
- 4.39.6.4 Electric heaters shall be controlled in steps as specified in the Supplementary Specification, with contactors.
- 4.39.6.5 The control circuit shall be interlocked with the supply air fan and shall only be in operation if the fan is running.
- 4.39.6.6 Where three-way valves are used it shall be in the full by-pass position when the system is off.

- 4.39.6.7 Three-way valves shall be fitted with balancing valves in the by-pass leg with the valve adjusted to ensure that the flow resistance across the by-pass leg shall equal the coil resistance at full flow.
- 4.39.6.8 The following interlocks shall be provided for electric heaters where used;
- ? heater shall not be on unless the fan is on
 - ? a fire protection high temperature thermostat shall be provided in the supply air duct to stop the fan if the air temperature exceeds 50°C and to switch all heaters off
 - ? a pressure switch or flap type mercury switch shall be fitted in the supply air duct to ensure that the heaters cannot be on unless air flow is established
 - ? provision to ensure that heating and cooling cannot be on simultaneously.
- 4.39.7 Control of Air Handling Unit Equipped with Direct Expansion Cooling Coil and Electric Elements for Heating
- 4.39.7.1 Both heating and cooling shall be controlled by a single room or return air sensor and controller as specified, generally as per 4.39.6 above.
- 4.39.7.2 In the cooling mode step control matching the refrigerant side with on/off, unloading/loading of compressors shall be provided.
- 4.39.7.3 Compressor interlocks preventing operation unless heat rejection equipment is functioning shall be provided.
- 4.39.8 Condensing Pressure Control
- 4.39.8.1 Cooling towers, evaporative condensers and air-cooled condensers shall be provided with head pressure control to maintain condensing temperatures within the limits recommended by the compressor manufacturer.
- 4.39.8.2 Aerofoil dampers with proportional control shall be used on cooling towers and evaporative condensers to match cooling capacity with system heat rejection whilst saving on fan energy.
- 4.39.8.3 Other methods of condensing pressure control, such as variable fan speed and fan cycling will only be considered if the head pressure can be controlled within the limits recommended by the compressor manufacturer.
- 4.39.9 Control Valves and Actuators
- 4.39.9.1 Control valves shall be the reversible globe type, either single, two or three ported or angle type as required, suitable for a working pressure of 900 kPa or 1? times the operating pressure of the system, whichever is the greatest, for the specified fluid and fluid temperature to be controlled.
- 4.39.9.2 Single ported control valves with port sizes larger than 25mm in diameter shall, whenever possible, be installed so that flow tends to open the valve.
- 4.39.9.3 The design and materials of the valve and its operating motor shall be such that leakage of fluid from the stem seal cannot cause corrosion, freezing or overheating of any working part. Valves of 40mm and smaller, shall have cast bronze bodies with screw ends.
- 4.39.9.4 Valves between 50 and 80mm shall be of cast bronze, cast steel or cast iron with screwed or flanged connections. Valves of 100mm and larger, shall be of cast steel or cast iron with flanged connections. Valve trim (valve plug, seat rings, valve stem guide bushings, valve guide bushings, valve stem and internal stuffing box parts), shall be of austenitic stainless steel or other hard facing materials suitable for the fluid to be controlled.
- 4.39.9.5 All control valves shall be provided with readily visible position indicators.

- 4.39.9.6 Electric actuators shall be of either the electric solenoid operated type or electric motor operated type.
- 4.39.9.7 Electric motor type actuators shall be of the shaded pole or capacity induction type capable of stopping at any point in the cycle or rotating in any direction. Provision shall be made for manual operation.
- 4.39.9.8 Electric actuators shall be installed in positions where they will not be subjected to any damp conditions due to condensation or overheating.
- 4.39.9.9 Actuator and valve and damper combinations shall be selected to suit the particular duty.

All valves and actuators on a installation shall be of the same manufacturer.
- 4.39.9.10 Control valves with their actuators shall be installed in readily accessible positions for maintenance purposes and where position indicators are clearly visible.
- 4.39.9.11 Where fail safe controls are specified, actuators shall be provided with spring return to either the open or closed position or alternatively solenoid valves shall be added for this purpose. Solenoid valves shall fail either to the open or closed position as required by the system.
- 4.39.9.12 Damper actuators shall be selected to suit the specified control requirements and with sufficient torque output to drive the dampers smoothly without straining or overloading.
- 4.39.9.13 Damper actuators shall be mounted in accessible positions for maintenance and setting purposes.
- 4.39.9.14 Linkages between actuators and dampers shall be adjustable.
- 4.39.9.15 Thermostatic expansion valves shall be of the gas charged type with external superheat adjustment and solder joint or flanged pipe connections. On coils where the refrigerant pressure drop through the coils exceeds 15 kPa, the expansion valve shall be provided with an external equaliser to the suction line at a point beyond the remote bulb. Valves shall be able to move from fully open to fully closed on not more than 3°C change in superheat. The superheat setting shall be between 4 and 8°C and shall be as recommended by the coil manufacturer.

4.40.0 THERMOSTATS AND HYGROSTATS

- 4.40.1 Thermostats and hygrometers or alternatively temperature and humidity transmitters in occupied areas, shall be provided where indicated on the drawings and shall be installed against the wall at a height of approximately 1,5 metres from the floor. Units mounted against outside walls, shall be provided with insulated bases.
- 4.40.2 Temperature sensing primary elements shall be either bimetal strips, sealed bellows or resistance wires.
- 4.40.3 Humidity sensing primary elements shall be either human hair, leather, plastic or of the hygroscopic resistance type.
- 4.40.4 Duct, pipe and tank thermostats shall be of the capillary remote bulb immersion type. Alternatively, thermostats controlling air temperatures may have fast response coiled sensing elements.
- 4.40.5 Sensing elements in piping and tanks shall be installed in oil filled separable immersion wells, screwed into the pipe or tank. Immersion wells shall be of copper or brass. Small diameter pipes shall be enlarged at points where sensing elements are installed. Sensing elements in ducts shall be located where they will respond to a representative temperature within the duct.
- 4.40.6 Thermostats and hygrometers mounted out of doors shall be provided with splash proof enclosures.
- 4.40.7 Capillary type thermostats shall be installed at a height of approximately 1,5 metres above floor level in easily accessible positions for adjustment and maintenance purposes. Thermostats

mounted against insulated ducts or pipes, shall be mounted on stand-off brackets. Capillary tubing shall be neatly installed and coiled where necessary and shall be protected against possible damage.

- 4.40.8 Fire protection and overheat thermostats shall be of the rigid stem insertion type.
- 4.40.9 Thermometers shall be provided in piping, ducts and tanks at the location of all control thermostats (not at limit or safety thermostats). Thermostats having built in thermometers, are also acceptable.
- 4.40.10 Thermostats and hygrometers shall not be installed in positions where they are subjected to direct sunlight. Thermostats near electric heater elements or other hot surfaces, shall be shielded against radiation.
- 4.40.11 Thermostats and hygrometers shall be protected against dust, dirt, corrosive fumes, chemicals and moisture.
- 4.40.12 Unless otherwise specified in the Supplementary Specification, all thermostats and hygrometers shall be of the relay-operated type.
- 4.40.13 Electric control relays shall be mounted inside the electrical switchboards.
- 4.40.14 Relays shall be suitable for the supply voltage required and shall have a contact rating well in excess of the load.