REPUBLIC OF KENYA
MINISTRY OF HEALTH

EAST AFRICA’S CENTERS OF EXCELLENCE FOR SKILLS AND TERTIARY EDUCATION IN BIOMEDICAL SCIENCES

PROPOSED CONSTRUCTION OF EAST AFRICA’S KIDNEY INSTITUTE COMPLEX AT KENYATTA NATIONAL HOSPITAL (KNH) GROUNDS NAIROBI, KENYA

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HVAC SERVICES INSTALLATIONS
(ALL RATES EXCLUSIVE OF TAXES)

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1. **PART A: GENERAL MECHANICAL SPECIFICATION**

1.1. **General**
This section specifies the general requirements for plant, equipment and materials forming part of the Sub-Contract Works and shall apply except where specifically stated elsewhere in the Specification or on the Contract Drawings.

1.2. **Quality of Materials**
All plant, equipment and materials supplied as part of the Sub-Contract Works shall be new and of first-class commercial quality, shall be free from defects and imperfections and where indicated shall be of grades and classifications designated herein.

All products or materials not manufactured by the Sub-Contractor shall be the products of reputable manufacturers and so far as if they had been manufactured by the Sub-Contractor.

Materials and apparatus required for the complete installation as called for by the Specification and Contract Drawings shall be supplied by the Sub-Contractor unless mention is made otherwise.

Materials and apparatus supplied by others for installation and connection by the Sub-Contractor shall be carefully examined on receipt and stored. Should any defects be noted, the Sub-Contractor shall immediately notify the Engineer.

Defective equipment or that damaged in the course of installation or tests shall be replaced or repaired to the approval of the Engineer.

1.3. **Regulations and Standards**
The Sub-Contract Works shall comply with the current editions of the following:

(a) The Kenya Government Regulations.
(b) The United Kingdom Institution of Electrical Engineering Regulations for the electrical equipment of buildings.
(c) The United Kingdom Chartered Institution of Building Services’ Guides.
(d) The Kenya Bureau of Standards Specifications.
(e) British Standards and Codes of Practice as published by the British Standards Institution.
(f) The Local Council By-laws.
(g) The electricity Supply Authority By-laws.
(h) The Kenya Building Regulations.
1.4. Electrical Requirements

Plant and equipment supplied under this Sub-Contract shall be complete with all necessary motor starters, control boards, and other control apparatus. Where control panels incorporating several starters are supplied they shall be complete with a main isolator.

The supply power up to and including local isolators will be provided and installed by the Electrical Sub-Contractor. All other wiring shall be as described in the Particular Specification.

The sub-contractor shall supply three copies of all schematic, cabling and wiring diagrams for the Engineer's approval.

The starting current of all electric motors and equipment shall not exceed the maximum permissible starting currents described in the Kenya Power and Lighting Company Ltd's By-laws.

All electrical plant and equipment supplied by the Sub-Contractor shall be rated for the supply voltage and frequency obtained in Kenya, that is 415 volts, 50HZ, 3-phase or 240 volts, 50HZ, 1-phase as specified in the particular specification.

Any equipment that is not rated for the above voltage and frequencies may be rejected by the Engineer.

1.5. Transport and Storage

All plant and equipment shall, during transportation be suitably packed, crated and protected to minimise the possibility of damage, and to prevent corrosion or other deterioration.

On arrival at site all plant and equipment shall be examined and any damage to parts and protective priming coats made good before storage or installation.

Adequate measures shall be taken by the Sub-Contractor to ensure that plant and equipment do not suffer any deterioration during storage.

Prior to installation all piping, plant and equipment shall be thoroughly cleaned. If, in the opinion of the Engineer any equipment has deteriorated or been damaged to such an extent that it is not suitable for installation, the Sub-Contractor shall replace this equipment at his own cost.

1.6. Site Supervision

The Sub-Contractor shall ensure that there is an English-speaking supervisor on the site at all times during normal working hours.

1.7. Installation

Installation of all special plant and equipment shall be carried out by the Sub-Contractor under adequate supervision form skilled staff provided by the plant and equipment manufacturer or his appointed agent, in accordance with the best standards of modern practice to the relevant regulations and standards described under clause 2.3 of this section.
1.8. Testing

1.8.1. General

All testing shall be carried out to the entire satisfaction of the Engineer.

The following sub-clause are intended to define the Sub Contractor's responsibilities with respect to testing and inspection.

1.8.2. Materials Tests

All materials for plant and equipment to be installed under this sub-contract shall be tested, unless otherwise directed, in accordance with the relevant B.S. Specification concerned.

For materials where no B.S Specification exists tests are to be made in accordance with the best modern commercial methods to the approval of the Engineer having regard to the particular type and application of materials concerned.

The Sub-Contractor shall prepare specimens and performance tests and analyses to demonstrate conformance of the various materials with the applicable standards.

If stock material, which has not been specifically manufactured for the plant and equipment specified is used, then the sub-contractor shall submit satisfactory evidence to the Engineer that such materials conform to the requirements stated herein in which case test of material may be partially or completed waived. Certified mill test reports of plates, piping and other materials shall be deemed acceptable.

1.8.3. Manufactured Plant and Equipment - Works Tests

The rights of the Engineer relating to the inspection, examination and testing of plant and equipment during manufacture shall be applicable to the Insurance Companies or Inspection Authorities so nominated by the Engineer.

The sub-contractor shall give two weeks’ notice to the Engineer of the manufacturer's intention to carry out work tests and inspection.

The Engineer or his representative shall be entitled to witness such tests and inspections. The costs of such tests and inspections shall be borne by the Sub-Contractor.

Six copies of all test and inspection certificates and performance graphs shall be submitted to the Engineer for his approval as soon as possible after the completion of such tests and inspections.

Plant and equipment which is shipped before the relevant test certificate has been approved by the Engineer shall be shipped at the Sub-Contractor's own risk and should the test and inspection certificate not be approved, new tests may be ordered by the Engineer at the Sub-Contractor's expense.
1.8.4. **Pressure testing**

All pipework installation shall be pressure tested in accordance with the requirements of the various sections of this Specification. The installation may be tested in sections to suit the progress of the works but all tests must be carried out before the work is buried or concealed behind building finishes. All tests must be witnessed by the Engineer or his representative, and the Sub-Contractor shall give 48 hours’ notice to the Engineer of his intention to carry out such tests.

Any pipework that is buried or concealed before witnessed pressure tests have been carried out shall be exposed at the expense of the Sub-Contractor and the specified tests shall then be applied.

The Sub-Contractor shall prepare test certificates for signature by the Engineer and shall keep a progressive and up-to-date record of the sections of the work that have been tested.

**1.9. Colour Coding**

Unless stated otherwise in the Particular Specification all pipework shall be colour coded in accordance with the latest edition of B.S.1710.

**1.10. Welding**

1.10.1. **Preparation**

Joints to be made by welding shall be accurately cut to size with edges sheared, flame cut or machined to suit and the required type of joint. The prepared surfaces shall be free from all visible defects such as laminations, surface imperfections due to shearing or flame cutting operation, etc., and shall be free from rust scale, grease and other foreign matter.

1.10.2. **Method**

All welding shall be carried out by the electric arc process using covered electrodes in accordance with B.S. 639.

Gas welding may be employed in certain circumstances providing that prior approval is obtained from the Engineer.

1.10.3. **Welding Codes and Construction**

All welded joints shall be carried out in accordance with the following specification:-

a) **Pipe Welding**

All pipe welds shall be carried out in accordance with the requirements of B.S. 806.

b) **General Welding**

All welding of mild steel components other than pipework shall comply with the general requirements of B.S.5135:1974.
1.10.4. **Welder's Qualifications**

Any welder employed on this sub-contract shall have passed the trade test as laid down by the Government of Kenya.

Trade engineer may require to see the appropriate certificate obtained by any welder and should it be proved that the welder does not have the necessary qualifications the Engineer may instruct the Sub-Contractor to replace him by a qualified welder.
GENERAL MECHANICAL VENTILATION AND AIR CONDITIONING SPECIFICATION
2. PART B: GENERAL MECHANICAL VENTILATION AND AIR CONDITIONING SPECIFICATION

2.1. GENERAL

This section specifies the general requirements for mechanical ventilation and air conditioning plant, equipment and materials forming part of the Sub-Contract works and shall apply except where specifically stated elsewhere in this Specification or on the Contract Drawings.

2.2. INSTALLATION

Installation of all ductwork, plant and equipment shall be carried out under adequate supervision from skilled staff in the relevant codes and standards specified herein.

The Sub-Contractor shall be responsible for ensuring that sufficient provision is made to prevent the transmission of vibration from equipment to the supporting structure. In the case of fans, this shall be done by rot and vermin-proof flexible connections and anti-vibration mountings of an approved type.

The Sub-Contractor shall ensure that all ducting systems are provided with sufficient access hatches complete with covers, for maintenance purposes.

Dampers and other user equipment shall be installed with adequate access for operation and maintenance. Where dampers and other operational equipment are unavoidably installed beyond normal reach and in such a position as too be difficult to reach from a short step ladder, extension spindles shall be provided.

The variety and type of supports for ducts, and fans shall be kept to a minimum and their design shall be such as to facilitate quick and secure fixing to metal, concrete, brickwork and wood.

Where the design of the structure is in reinforced concrete, supports shall be secured to the structure by means of redheads, raw bolts or other approved means.

Where the Sub-Contractor proposes to secure his supports by other means than to the main structural concrete, he shall consult with the Engineer before proceeding.

2.3. TESTING AND INSPECTION

2.3.1. Site Test

The Sub-Contractor shall supply all instruments and equipment necessary to carry out Site Tests and shall arrange with other Sub-Contractors for the testing of associated equipment which may affect the performance of the plant installed under these Sub-Contract Works.

2.3.2. Site Tests- Fans

All fans shall be charged with a suitable lubricant and shall be tested upon completion of the ancillary system erection to ascertain that the performance of each fan complies with the requirements of the Specification.
2.4. COMPLETION OF WORKS - BALANCING AND COMMISSIONING

Following the Site Tests and prior to handover, mechanical ventilation or air conditioning systems shall be balanced by means of grilles, dampers and other special controls installed, so as to give the required air flow rates and where applicable the desired temperatures, pressures and humidity conditions in all areas served by the said systems.

The complete system shall be balanced and commissioned as a whole. Sectional balancing and commissioning on any one part of the system where this excludes final complete system balancing and commissioning, shall not be accepted.

Test volumes within ducts shall be within + or - 5% of the design volumes, and volumes at grilles and diffusers shall be within + or - 10% of the design volumes.

When the system has been balanced to the satisfaction of the Engineer, it shall be run under complete automatic control for 72 hours continuous operation to ascertain any faults in operation before acceptance and handover. Any faults discovered during this time shall be corrected and a further test or tests of 72 hours duration shall be carried out to ensure satisfactory operation, all at the expense of the Sub-Contractor.

2.5. DUCTWORK

The Sub-Contractor shall supply, deliver and erect all ductwork as shown on the Contract Drawings.

All ductwork shall be manufactured in accordance with the Heating and Ventilation Contractors Association (H.V.C.A.) Specification DW/121, current edition except where stated otherwise.

Ductwork shall be manufactured from galvanised mild steel sheet unless otherwise specified. All external ductwork shall be manufactured from black mild steel sheet and galvanised after manufacture. All seams shall be of lock form type. All ductwork systems shall be complete with all necessary dampers, bends, tees, tapers, transformation and special pieces.

Where removal is required for access or maintenance, ducting shall be provided with steel angle flange joints suitably painted and protected.

Only bends type 1 - 7 inclusive as detailed in the H.V.C.A. Specification will be permitted.

Only duct connections type 42 - 44 inclusive 53 and 54 as detailed in the H.V.C.A. Specification will be permitted. All joints shall be fixed as to be suitable for the direction of the air flow.

All positions of plant and ductwork shall be checked on site before detailed manufacturing drawings are prepared and ductwork manufacture commenced.

Transformation and paper pieces shall, wherever possible, be constructed so that the included angle does not exceed 30 degrees C.

All flanged joints shall be sealed by the use of asbestos string, compressed between the flanges, and where slip joints occur, these shall be sealed by "Prestik" or other similar suitable jointing compound and adhesive tape 40mm wide. Exposed sheet metal edges shall be painted with galvanize before sealing.

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Dampers shall be of aerofoil section and manufactured from galvanised mild steel sheet. Damper blades shall not exceed 150mm in width and the edges of the blades shall be sealed with a 3mm thick felt or rubber seal to minimise leakage. Operating quadrants shall be provided with locknuts and the quadrant shall be clearly marked with ‘Open’ and ‘Closed’ positions. Multileaf damper blades shall be operated by one arm through a linkage external to the duct.

The Sub-Contractor shall provide sufficient access doors and handholds in the ductwork for the purpose of maintenance and inspection. Access doors shall be of the hinged type and door openings in the ductwork shall be adequately stiffened and made airtight with purpose made rubber gaskets around the door perimeter.

All supports and brackets shall be wire brushed and painted one coat of red oxide paint prior to and after erection. All nuts and bolts shall be sheradized. The fastening of electrical cables to ductwork will not be permitted.

Where ductwork has insulation incorporating an external vapour seal, the ductwork shall be insulated from the support by a rot-proof softwood, hardwood or other suitable closed cell insulator of not less than 25mm greater thickness than the insulation to be applied so that the vapour seal may be bonded to the face of the timber, all as detailed in Clause 6.4 of the H.V.C.A. Specification DW/121, latest edition.

Where ductwork passes through floors and walls, etc., galvanised sheet sleeves or builders work timber frames shall be provided. The space between duct and sleeve or frame shall be paced with asbestos rope or mastic to prevent air movement or noise transmission from one space to another. Ducts must not come into direct contact with the building fabric.

Hangers and brackets shall be manufactured from rolled mild steel angle or channel sections and shall generally be of the drop rod hanger or cantilever type. The hangers shall be spaced to ensure adequate support and where practicable shall be fitted at each ductwork joint.

The Sub-Contractor shall supply and install, where called for, louvred inlets and outlets with insect-proofed screens. The louvres shall be constructed throughout from extruded aluminium sections and shall have a lacquered or anodised finish to prevent corrosion. The louvres shall be weather-proof and have a free area of not less than 50%.

The Sub-Contractor shall ensure that wherever fans or similar equipment are connected to the ductwork system, the connections are made with a heavy duty rot and vermin-proof neoprene, or similar material, flexible connection to prevent vibration transmission to the ductwork or building fabric. Flexible connections shall be secured by a pre-drilled mating flange, or when fixing to a spigot, the spigot should be beaded and a jubilee clip or split flat iron ring should be used.

The Sub-Contractor shall provide test holes in all branch ducts and in the main duct on the discharge of the fan. The holes shall be suitably spaced in accordance with B.S. 848, shall be situated on a straight length of ductwork and where possible, not less than 2 metres downstream or any bends or damper. After the completion of testing the Sub-Contractor shall provide and fix properly metal or plastic plugs to all test holes. The use of rubber or cork bungs will not be permitted.
2.6. INSULATION

2.6.1. General Description

All heated, cooled and recirculated air ductwork shall be insulated.

Insulation shall be of 25mm thick expanded polystyrene sheet, or spray applied polyurethane foam to a uniform thickness of 25mm. Polystyrene shall be fixed so that the edges butt closely without gap and insulation shall overlap at corners by the thickness of the insulation. The sheet shall be fixed by means of a suitable adhesive and plastic impingement pines attached to the ductwork.

2.6.2. Ductwork in Plant Rooms

The insulation described in Clause 5.1 above shall be finished by the application of a 15mm thick layer of hard setting plastic compound trowelled to a smooth finish. All corners shall be protected by setting in a 1mm thick aluminium angle strip into the hard setting finish. Insulation shall be bevelled to angle of 45 degrees at all connecting flanges, access hatches and all other places where operation or maintenance is likely to cause the breaking of the insulation.

The insulation shall then be given a vapour sealing by the application of two coats of anti-condensation paint.

2.6.3. Ductwork External to Plant Rooms

The insulation described in Clause 5.1 above shall be finished by the application of two coats of bitumastic.

2.7. FINISH PAINTING

Upon completion of the installation and after all tests have been carried out to the satisfaction of the Engineer the plant, equipment, supports etc., shall be examined and all priming coats damaged during erection made good.

Any plant or equipment, ductwork, etc., which is to be insulated, shall have had the priming paint protection made good before the application of the insulation.
GENERAL SPECIFICATION FOR MECHANICAL VENTILATION INSTALLATION
3. PART C: GENERAL SPECIFICATION FOR MECHANICAL VENTILATION INSTALLATION

3.1. SCOPE OF WORK

The scope of the works comprises Installation, Testing, and Commissioning of Mechanical Ventilation and Air Conditioning systems in accordance with Specifications and drawings.

All the necessary elements and details for complete system are to be included. Excluded from the specifications are the following:-

- All concrete works
- All block work
- Electrical wiring, isolators and switch boards, except internal wiring for control system from a local isolator.

3.2. SYSTEM COMPONENTS

Dimensions and capacities of ducts and fans are calculated and based on a specific requirements of air, and on an assumed resistance through grilles, silencers etc. However the installer shall be responsible for the correct functioning of the system. Subsequently it is therefore his duty to size the systems’ components with consideration to his offered equipment.

3.3. DRAWINGS

The Engineer’s drawings show the main layout and principles for the Ventilation and Air Conditioning Systems. If need for further detailing is required in order to carry out the work, working drawings and details shall be produced for approval by the Engineer before the work is executed.

In preparation of the working drawings are care should be taken to coordinate the Ventilation and Air Conditioning works with other services involved and avoid any interference with these.

3.4. MATERIALS AND WORKMANSHIP GENERALLY

In the specification, equipment is generally described according to capacities and a given standard in order to aid in identification of the particular equipment to satisfy specifications. The equipment selected shall be of reputable manufacture with adequate Back-Up service.

If the Engineer finds it necessary, samples of the materials will be submitted for approval before placing an order. The Engineer shall reject any materials which he finds to be of unsatisfactory quality.

Works shall be carried out by competent workmen under experienced supervision. The Engineer shall have the authority to have any substandard work or equipment redone and/ or equipment replaced.
3.5. DUCTWORK GENERALLY

3.5.1. Ductwork

All seams, joints and connections to plant shall be so made as to reduced air leakage to a minimum. Internal roughness and obstructions to airflow will not be accepted. Sharp edges or corners on the outside of ductwork, flanges, supports, etc. will not be accepted. Any part of galvanized ductwork where the galvanizing is damaged during manufacture or erection shall be painted with two coats of aluminium, zinc or other corrosion – resisting paint to the approval of the Engineer.

Where ducts pass through roofs (and external walls where applicable) these shall be fitted with angle flanges and weather cravats to ensure a weather-proof fitting to the building structure.

Connections to equipment shall be made with angle flanged joints. Ductwork which may have to be moved to enable plant to be removed shall incorporate angle flanged joints. For long duct runs, angle flanged joints shall be included at intervals to facilitate any subsequent alternations.

Bends and offsets shall have a minimum throat radius equal to the width of the duct. Where short radius elbows are indicated or agreed by the Engineer as necessary due to site limitations the dimensions and internal vane (s) shall be in accordance with HVCA publication DW/121.

Ductwork shall be constructed by galvanized, cold rolled, close annealed patent flattened sheets. Tests holes shall be provided in branch ducts from grilles and there shall be three or four tests holes on side of duct according to duct depth at each test position. At branch positions there shall be one test hole. Air tight swivel type metal covers shall be fitted over the test holes in such a manner that they shall be readily removed as required.

3.5.2. Rectangular ductwork

Construction of ductwork shall be as per the following Guidelines:

- Up to 300mm longer side – 22 S.W.G.
- over 300mm and up to 460mm longer size – 20 S.W.G.
- over 460mm and up to 900mm longer side 18 S.W.G (stiffening to be 25mm x 25mm x 3mm. M.S angle at slip joints at 180mm spacing)
- Over 900mm and up to 1370mm. longer side 16 S.W.G. (stiffening to be 30mm x 30mm x 3mm M.S angle at 900mm spacing).
- Over 1370mm longer side – 14 S.W.G. (Stiffening to be 40mm x 40mm x 5mm M.S angle at 900mm. spacing).

Ductwork constructed from 22 and 20 S.W.G sheet shall have folded locked seams and ductwork constructed from 18, 16 and 14 S.W.G. sheets shall have riveted seam with 8 S.W.G rivets at 2” pitch.
Joints for ductwork having a side greater in width than 610mm shall be flanged by means of 30mm x 30mm x 3mm mild steel angles.

Mild steel used as flanges or stiffeners shall be riveted to the ductwork, with 8 S.W.G rivets at 2” pitch. The joint faces of flanges shall be drilled for 10mm bolts at 75mm pitch.

Air tight access doors shall be provided on the ductwork wherever indicated on the drawings. The access doors, of sufficiently heavy construction to avoid distortion, complete with handles, shall be secured by brass wing nuts screwed into studs provided, on galvanized mild steel stiffening frames riveted, or bolted to the ductwork. The access doors shall be provided with felt or rubber gaskets to ensure that when closed they are perfectly tight.

The ductwork shall be installed with all joints air tight and adequately stiffened and braced shall have the largest radius possible with a minimum throat radius of one diameter if possible. Square or miter elbows will only be allowed where shown on the drawings. Turning vanes shall be fitted in square or miter elbows.

Transformer pieces except where situated on fan suction shall be constructed so that the angle on any side does not exceed 15° to the axis of the duct where possible.

Branch ducts shall enter main ducts expansion sections where possible. Where branch ducts occur, at taper or transformation pieces, the length of such pieces in the main duct shall be symmetrical about the axis of the branch.

3.6. BRACKETS AND SUPPORTS

Supports and brackets for ductworks shall be made adjustable for height, spaced to ensure support and where practicable shall be fitted at each joint of the ductwork. Vertical ductwork shall be supported at each floor level, horizontal ducts at intervals not exceeding 2280mm and adjacent to fans, canvas joints and other equipment. All members of supports in contact with metal ductwork shall be galvanized after fabrication.

Socketed joints shall have a minimum overlap of 50mm in the direction of flow. The joint shall be made with an approved type jointing compound with bolts or rivets at centres not exceeding 50mm. wherever access cannot be made for riveting or bolting self-tapping screw of the shortest length which will give a satisfactory joint shall be used in lieu of the rivets or bolts, on size or diameters up to 530mm. All slip joints on circular ductwork are to have a spigot carefully swaged damper leaves shall be multi leaf type. The quadrants shall be of robust construction and securely fixed to the ductwork. The leaves shall be linked with a connecting rod and the ends of the spindle shall be housed in bearings. Dampers are to indicate the full and closed positions and are to be marked and then locked after air Volume has been set.

3.7. JOINTS

3.7.1. Flexible Joints

Flexible joints shall be provided on fan inlet and outlet connections and elsewhere on the ductwork where indicated. They shall be over the full cross-sectional area of the mating fan inlet or outlet section. The ends of the duct and fan connections shall be in line.
Flexible joints shall consist of, or be protected by, material having a fire penetrating time of at least fifteen minutes when tested in accordance with BS 476 Part 1 Section 3. The material shall be of the glass fibre cloth type, canvas or other approved material. The width of joints from metal edge to metal edge shall not be less than 80mm and more than 250mm.

All flexible joints other than fan inlet connections shall be between flanged ends. The flexible material flange shall be backed by an angle or flat iron flange and the flexible joint flat iron bar used with fan inlets shall not be less than 5mm thick.

3.7.2. Flexible Connections

Where flexible connections are indicated or required between rigid ductwork and particular components or items of equipment, the internal diameter of the flexible duct shall be equal to the external diameter of the rigid ductwork and of the spigot type. The use of flexible duct between rigid sections of sheet metal ductwork to change direction or plane will not be permitted except where indicated or expressly authorized by the Engineer.

The flexible duct shall have a liner a cover of tough tea-resistant fabric equal in durability and flexibility to glass fibre shall be impregnated and coated with plastics. It shall be reinforced with a bonded galvanized spring steel wire helix or glass fibre cord or equal and shall be bonded to cover to ensure regular convolutions.

Alternatively the flexible duct shall consist of flexible corrugated metal tubing of stainless steel, aluminium, tinplated steel or aluminium coated steel. The metal may be lined on the inside or the outside or both with plastics materials.

The joints to rigid spigots shall be sealed with a brush coat of pipe jointing paste or mastic compound. Ducts up to 150mm diameter shall be secured with a worm drive type hose clip complying with BS 3628. Ducts over 150mm diameter shall be secured with band clip.

The frictional resistance to air flow per unit length of the flexible duct shall not exceed 50% more than the frictional resistance per unit length of galvanized steel ducts of equivalent diameter. The radius ratio R/D for bends shall not be less than 2, where R is the centre line radius and D is the diameter of the flexible duct.

Flexible ducts shall be suitable for an operating temperature range of 18°C to 120°C and shall comply with BS 476 Part 1, Section 2, Clause 7 (Clause 1; surface of very low flame spread).

3.8. FINISH PAINTING

Upon completion of the installation and after all tests have been carried out to the satisfaction of the Engineer, the plant, equipment, supports, etc. shall be examined and all priming coats damaged during erection made good.

Any plant or equipment, ductwork, etc., which is to be insulated, shall have had the priming paint protection made good before the application of the insulation. After the above procedures have been carried out to the satisfaction of the Project Manager, the various surface shall be given the necessary preparation as recommended by the paint and insulation manufacturers and finish painted in colours to be agreed between the Sub-Contractor and Project Manager, at a later date.
For the purposed of the Specification, however, it shall be deemed that the sub-contractor’s tender price was based on the identification requirements for the various services detailed in Code of Practice DW/161 Identification of Ductwork as published by the H.V.A.

3.9. AIR INTAKES AND OUTLETS

Unless otherwise indicated fixed louvers on external walls will be fitted at air intake and outlet positions. A galvanized steel wire mesh screen of 20mm diamond mesh and at 2mm diameter wire and complete with a frame of galvanized steel rod with securing lugs or of flat iron shall also be fitted on the inner side of the louvers.

3.10. FANS

3.10.1. General

Fans shall capable of giving the specified performance when tested in accordance with BS 848. Although estimated values of the resistance to airflow of items of equipment may be indicated, this does not relieve the Contractor to the responsibility for providing fans capable of delivering the required air volume flow through the system.

The make and design of fans shall be approved by the Engineer and evidence supporting noise levels and fan efficiencies shall be provided. Where fans are supplied with noise attenuations, full details of the attenuations shall be given.

Belt driven fans shall be fitted with pulleys suitable for V-belts; pulleys of the taper lock type may be used for drivers up to 30KW output. Alternatively, and in any case above 30KW output, pulleys shall be secured to the fan and the motor shafts by keys fitted into machined keyways. Pulleys shall be keyed to the fan shaft in the overhung position. Keys shall be easily accessible so that they can be withdrawn or tightened and they shall be accurately fitted so that the gib head does not protrude beyond the end of the shaft.

Machined bolts, nuts and washers only shall be used for the assembly of fans; all bearing surfaces for the heads of bolts or washers shall be count faced. Holding down bolts for fans and meters shall be square section under the head or be fitted with snugs to prevent them tuning in the fan base plate when the nuts are tightened.

Any fan which is too large or too heavy for safe manhandling shall be provided with eyebolts or other lifting facilities to enable mechanical lifting equipment to be used.

3.10.2. Axial Flow Fans

Axial flow fans shall be of either the single stage type or the multi-stage contra-rotating type with each impeller mounted on an independent motor. Casings shall be rigidly constructed of mild steel stiffened and braced to obviate drumming and vibration. Cast iron of fabricated steel feet shall be provided where necessary for bolting to the base or supports. Inlet and outlet ducts shall terminate in flanged rings for easy removal. The length of the fan (s) and motor(s) shall also terminate in flanges in order that the complete section may be removed without disturbing adjacent ductwork. Electrical connections to the motor(s) shall be through an external terminal box secured to the casing. Impellers shall be of steel or aluminium, the blades shall be secured to the hub or the blades and the hub shall be formed in one piece. The hub shall be keyed to a substantial mild steel shaft and the whole statically balanced. Blades shall be of aerofoil section. Shafts shall be carried in
two bearings which may be ball roller or sleeve type. Lubricators shall be extended to the outside of the casing.

Where axial flow fans are driven by a motor external to the casing the requirements for pulleys and for V-belt drives and guards shall be met. Unless otherwise indicated a guard is not required for any part of a drive which is within the fan casing. An access door of adequate size shall be provided.

Where axial flow fans of the bifurcated type are indicated the motors shall be out of the air stream. Motors may be placed between the two halves of the casing in the external air or may be placed within the fan casing provided that effective ventilation is given to the motor. Where hot gases or vapours are being handled the motor and the bearings shall be suitable for operation at the temperature they may experience.

3.11. DAMPERS

3.11.1. General

Sufficient dampers shall be provided to regulate and balance the system. Dampers on grills or diffusers shall be used for fine or secondary control. All dampers shall be sufficiently rigid to prevent fluttering. Unless otherwise indicated, the air leakage past dampers in the fully-closed position shall not exceed 5% of maximum design air flow in the duct. All duct dampers except fire dampers and self-closing flaps shall be fitted with locking devices and position indicators. Dampers shall be generally in accordance with the appropriate HVCA Specification.

Each Primary control damper shall be fitted with a non-corrodible label stating the actual air flow in M3/S and the cross-sectional area. Alternatively, these figures shall be painted in a visible position on the adjoining ductwork or insulation. The position of a damper as set after final regulation and balancing be indelibly marked on the damper quadrant.

3.11.2. Butterfly dampers

Butterfly dampers shall each consist of two plates edge seamed, and of the same thickness of material as that from which the associated duct is made, and rigidly fixed to each side of a mild steel operating spindle, the ends of which shall be turned and housed in non-ferrous bearings.

3.11.3. Bifurcating dampers

Bifurcating dampers shall be of 2mm thick sheet for sizes up to 450mm square. For larger sizes, the thickness shall be as indicated. Damper plates shall be rigidly fixed to square section mild steel spindles the ends of which shall be turned and housed in non-ferrous bearings.

3.11.4. Multi-leaf dampers

Multi – leaf dampers shall consist of two plates of material of the same thickness as the associated duct and rigidly fixed to each side of an operating spindle, the ends of which shall be housed in brass, nylon, oil impregnated sintered metal, PTFE impregnated or ball bearings. The ends of the spindles shall be linked such that one movement of the operating handled shall move each leaf an equal amount. An inspection door shall be provided adjacent to each multi-leaf damper.

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On low velocity systems only, multi-leaf damper blades may be of a single plate, at least 1.6mm thick and suitably stiffened, and the blade linkages may be within the duct. Those dampers shall have bearings and inspection doors as specified above.

3.11.5. **Damper Quadrants and Operating Handles**

Quadrants and Operating handles shall be of die-cast aluminium with the words "OPEN" and "SHUT" cast on the Quadrants. Quadrants shall be securely fixed to the damper spindles and shall be close-fitting in the quadrants hubs to prevent any damper movement when the damper levers are locked.

3.11.6. **Self-closing dampers**

Self-closing dampers shall be designed so as to present the minimum of resistance to airflow under running conditions, to take up a firm, non-fluctuating position under running conditions and to give a tight shut-off when closed. They shall incorporate rubber stops to prevent rattling and to give a tight shut-off when closed. They shall incorporate rubber stops to prevent rattling.

3.11.7. **Sliding Dampers**

Sliding dampers shall be provided only where indicated. They shall be of 2mm. thick sheet steel for size up to 450mm square. For larger sizes the thickness shall be as indicated. They shall run in guides lined with felt.

3.11.8. **Iris type dampers.**

Iris type dampers may be used in ducting up to 600mm, dia. Or 450mm square. The control shall be on the outside of the damper. The design shall be such that the leaves of the damper can be easily moved for adjustment.

3.12. **GRILLES**

3.12.1. **Supply & Return Registers**

Supply registers shall be manufactured from high grade, extruded Aluminium sections with lacquered finish and fixing shall be 32mm with bevelled edges.

The registers shall have a front set of blades parallel to the long dimension, of rear set of blades parallel to the short dimension, the blades being at 17mm centres and individually adjustable with opposed blade dampers.

3.12.2. **Extract grilles**

Extract grilles shall be similar to the Supply Registers described above with the exception that they have only one set of blades parallel to the long dimension.

3.12.3. **Fresh Air Grilles**

These shall be manufactured from sheet steel with steel fixing flanges and shall be galvanized after manufacture. An insect screen shall be fixed downstream.
3.12.4. **Diffusers**

These shall be manufactured from high grade extruded sections with lacquered finish, bevelled flanges and removable core. Fixing shall be by self-tapping screws through the duct into neck of the diffuser.

3.12.5. **Louvres**

Discharge and Fresh air Intake louvres shall be manufactured from mild steel and be galvanized after manufacture. A screen shall be fixed to the back of the louvres

3.13. **ATTENUATORS**

3.13.1. **General**

Purpose made attenuators and sound absorbing material shall be designed to air flow, have adequate strength and cohesion to resist erosion by air flow and do not produce dust. They shall be free of odour and proof against rot, damp and vermin and shall comply with the requirements as to fire and smoke hazards. Adhesives shall be compatible with the sound absorbent material and should preferably be non-flammable.

Where sound absorbent material and/or special attenuators are indicated they shall either reduce the sound level in the space, due to the equipment, to the specified value or shall give the specified sound level attenuation over the specified range of frequencies. Purpose made attenuators shall be tested in accordance with HVRA Laboratory Report No. 55 (Code for the measurement of the performance of unit silencers). The insertion loss and generated noise level for each octave band and the pressure loss of the silencer shall be stated.

Attenuators shall be suitable for internal air pressure of 100N/m², air stream temperatures of up to 40°C and free from air stream erosion for velocities up to 25m/s. The mineral wool lining shall be rot, vermin and fire-proof. Attenuator casing shall be pre-galvanized sheet steel with galvanized pre-drilled flanges.

3.13.2. **Rectangular Attenuators**

These shall be rectangular in section with splitters forming air passages in parallel. The mineral wool lining shall be resin bonded.

3.13.3. **Circular Attenuators**

Circular section attenuators will have a central pod. The mineral wool lining shall be retained by expanded steel. The end flanges shall be match drilled to suit the fan which they are fixed to.

3.13.4. **Acoustic lining**

Where indicated on the contract drawings, the ductwork shall be acoustically lined. The lining shall consist of resin bonded mineral wool 25mm, thick fixed to the ductwork by a suitable adhesive.
3.14. INSTRUMENTS

3.14.1. General

The instruments, gauges etc., detailed in this section shall be provided in addition to those associated with specific items of plate and detailed elsewhere, they shall be mounted in accessible positions and shall be easily read.

3.14.2. System Static Pressure Gauge

A system static pressure gauge shall be provided for the system. It shall consist of a small inclined manometer gauge similar to a filter gauge. The edge of the gauge shall be connected to the system and the other end shall be left open to the plant room but where fluctuation of the static pressure in the plant room may occur the gauge shall be connected across the main fan. Such fluctuations may be caused by wind pressure affecting large open air intakes to the plant room.

3.15. VIBRATION, NOISE AND SOUND INSULATION

3.15.1. Anti-Vibration Mountings

Fans, compressors, motors and any other vibration-inducing equipment shall be isolated from the building structure by anti-vibration mountings which shall be compressed machinery cork, spring or rubber dampers or rubber/metal bearers as indicated.

3.15.2. Noise

The noise produced by the installation in the spaces served, in any adjacent buildings and in the open air surrounding plant rooms shall be kept as low as possible. This shall be specially considered in the selection of fan motors, grilles and the internal finish and arrangements of extraction ducting.

Noise level information for fans based on octave analysis data, shall be stated. The reference level and the testing technique shall be stated.

The sound level in the spaces served, due to the equipment shall comply with the recommended design criteria given in the IHVE Guide (Table 13.1 of 1965 Edition). The maximum sound pressure level due to ventilation system must not exceed value mentioned below measured by a reference value of $2 \times 10 \times 10^3$ N/m$^2$ transferred to a logarithmic scale, and measured at any point 1.5 meters above the floor and 1.0 meters from the walls.

The maximum sound pressure level measured at any point 4 metres from the extract point must not exceed 55dB.

The maximum sound pressure level measured at any point 4 metres from fans must not exceed 60dB.
3.16. THERMAL INSULATION

3.16.1. General Description

All heated, cooled, and recirculated air ductwork shall be insulated.

Insulation shall be of 25mm thick expanded polystyrene sheet, or spray applied polyurethane foam to a uniform thickness of 25mm. Polystyrene shall be fixed so that the edges butt closely without gap and the insulation shall overlap at corners by the thickness of the insulation. The sheet shall be fixed by means of a suitable adhesive and plastic impingement pines attached to the ductwork.

3.16.2. Ductwork In Plant Room

The insulation described above in Clause 5.1 above shall be finished by the application of a 15mm thick layer of hard setting finish. Insulation shall bevelled thick to angle of 45° at all connecting flanges, access hatches and all other places where operation or maintenance is likely to cause the breaking of the insulation.

The insulation shall then be given a vapour sealing by the application of two coats of anti-condensation paint.

3.16.3. Ductwork External to plant Rooms

The insulation described in Clause 5.1 above shall finish by the application of two coats of bitumastic.

3.17. ELECTRICAL EQUIPMENT AND WIRING

3.17.1. Scopes

The responsibility for electrical equipment and wiring shall be as defined as below:-

An on-off starter shall be provided and placed in the appropriate position for connection of the fans required for the installation and within a time agreed with the Engineer fully detailed wiring diagrams for all connections to them shall be availed.

The Installer shall be responsible for the accuracy of all wiring diagrams provided by him and for the correct internal wiring of all pre-wired equipment supplied. The Installer shall reimburse the full cost of abortive or remedial work arising from any error in these aspects.

3.17.2. General

Unless otherwise indicated all electrical equipment and installation shall be suitable for use in ambient temperatures up to 40°C and relative humidities up to 90%. For tropical climates, electrical equipment shall be suitable for use in the temperature and humidity as indicated; it shall be proof against atmospheric corrosion, including that of saline air where relevant, and materials shall not be susceptible to mould growth or attack by termite and similar hazards.
3.17.3. **Electrical Motors**

Electrical motors shall comply with BS 170 2048 or with BS 2613 and BS 3979 as appropriate. All motors shall have Class E insulation (BS2757) and can be continuously rated.

They shall be screen protected (BS2817) unless otherwise indicated. Under all normal conditions without being overloaded. All motors larger than 0.75kw output shall be three phase, for motors above 15kw output the type of motor and method of starting shall be such as to limit the starting and run-up currents to three times the rated full load current unless otherwise indicated. No motor shall run faster than 25 rev/s unless otherwise indicated.

### 3.18. INSPECTION, COMMISSION AND TESTING

#### 3.18.1. General

Unless otherwise indicated tests shall be carried out in accordance with the appropriate BS or CP. Test certificates for works tests, site tests and tests required by BS shall be submitted in duplicate to the Engineer.

#### 3.18.2. Testing

Where an individual inspection or tests take place at outside the site of the works representatives of the Engineer will be required to be present.

Unless otherwise indicated the contract shall include the cost of all tests, necessary instruments, plant supervision and labour both at work and on site. The accuracy of the instruments shall be demonstrated where so directed by the Engineer.

The site test shall be of at least six hours duration. Any defects or workmanship, materials and performance maladjustments or other irregularities which become apparent during the tests shall be rectified by the supplier at his expense and the tests shall be repeated at his expense to the satisfaction of the Engineer.

The Supplier/Installer’s representative present at the site tests shall be fully conversant with the operation of the thermostatic controls and shall be expected to explain the operation and safety controls forming part of the installation to the employer’s representatives.

#### 3.18.2.1. Site Tests

The Installer shall supply all instruments and equipment necessary to carry out site tests and shall arrange with other parties for the testing of associated equipment which may affect the performance of the plants installed under these works.

#### 3.18.2.2. Site Tests-Fans

All fans shall be charged with suitable lubricant and shall be tested upon completion of the auxiliary system erection to ascertain that the performance of each fan complies with the requirements of the specification.
3.18.2.3. Completion of Works – Balancing and Commissioning

Following the site tests and prior to handover, Mechanical Ventilation or Air-Conditioning systems shall be balanced by means of grills, dampers and other special controls installed so to give the required air flow rates and where applicable the required temperatures, pressures and humidity conditions in all areas served by the said systems.

The complete system shall be balanced and commissioned as a whole. Sectional balancing and commissioning on any part of the system where this excludes final complete system balancing and commissioning shall not be accepted.

Test volumes within ducts shall be within +5% of the design volumes, and volumes at grills and diffusers shall be within +10% of the design volumes.

When the system has been balanced to the satisfaction of the project manager, it shall be run under complete automatic control for 72 hours continuous operation to ascertain any faults in operation before acceptance and handover. Any faults discovered during this time shall be corrected and another test or tests of 72 hours duration shall be carried out to ensure satisfactory operation, all at the expense of the Supplier/Installer.

During this phase, particular attention shall be paid to:

- The maintenance of cleanliness of all plant and extraction systems during construction and ensuring that extraction systems are cleaned through as part of commissioning.
- The protection of plant, particularly sensitive or fragile items, from the activities of other trades during construction and from dirt and mal operation during commissioning.
- The protection of electrical of electrical equipment from damp during construction and commissioning.

3.19. CONTROL SYSTEM

Particular attention shall be paid to the following features:

- Satisfactory operation of any automatic or manually operated sequence to be used in the event of fire.
- Safety in the event of failure and of sudden resumption of electricity supply.
- Satisfactory operation of safety interlocks designed for the protection of personnel, such as those associated with the high voltage electrically operated plant.

The following items shall be checked and/or tested and recorded on the site Test Certificate:-

- Set devised value of all control devices
- Satisfactory operation of equipment protection devices.
- Satisfactory operation of all sequencing operations and alternate working selections and automatic or manual change-over of duplicate plant.
3.20. **NOISE AND SOUND CONTROL**

Sound level reading shall be taken with a simple sound level meter using the ‘A’ scale weighting network. The spaces in which readings shall be taken shall be as agreed with the Engineer but will in general be the following:-

- Plant rooms
- Occupied rooms adjacent to plant rooms
- Outside plant rooms facing air intakes and exhaust to assess possible nuisance to adjacent accommodation. If the adjacent accommodation is private residential building
- Tests may be required at night.
- In the space served by the first grille or diffuser after a fan outlet.
- In any space where, by the addition of special silencing material or techniques of by classification of use, a low level of noise is clearly required.

Alternatively, sound level reading shall be taken using a sound analyzer to give an octave band analysis of the ground spectrum and to pinpoint the frequency values of peak sound levels. The spaces in which readings shall be taken shall be as agreed with the Engineer but will in general be as detailed in paragraph above.

3.21. **OPERATING AND MAINTAINANCE INSTRUCTION**

The Supplier/Installer shall demonstrate and explain the plant and the method of starting, running and stopping to such staff as the Engineer shall nominate. He shall provide three sets of operating and maintenance instructions which shall be enclosed in durable covers. The operating and maintenance instructions shall include:-

- A brief outline of the operation of the plant.
- Instructions on how to start and stop the plant, noting any safety and / or sequencing arrangements.
- Details of required maintenance with suggested frequency of action
- Details of all lubricating oils and greases required and filter replacement
- Details of each item of plant including the name and address of the manufacturer, type and model, serial number, duty and rating.

The operating and maintenance instructions shall be handed to the Engineer not later than at the end of the commissioning period.
3.22. **SPARE PARTS**

The Installer shall submit a priced list of any extra materials which he recommends should be purchased for the Ventilating and Air Conditioning Plants and all associated equipment and control gear and extras not supplied as standard. He shall be required to give a guarantee that he will hold sufficient running stock of spare parts for the maintenance of the equipment.

3.23. **MATERIALS AND WORKMANSHIP**

All materials shall be of adequate quality for the duty specified and the workmanship shall be in accordance with the best accepted modern practice. Unless otherwise stated the Mechanical Contractor shall be obliged to comply with the requirements of the latest edition of the relevant Bureau of Standards Specification where applicable. Failing this, the latest edition of the relevant Britain Standard Specification shall provide the required standard. If the Mechanical Contractor desires to use any other standard specification or code of practice, it shall be referred to the Engineer for approval.

3.24. **STRUCTURAL STEELWORK**

The structural steel used in the Mechanical Contract shall be mild steel to B.S. 15. Black bolts and nuts shall be in accordance with B.S. 916. Black metal washers shall be in accordance with B.S. 916.

High Strength friction grips, bolts, nuts and washers shall be in accordance with B.S. 3139, Part 1, and their application shall conform to B.S. 3139, Part 1, and their application shall conform to B.S. 3294, Part 1 torque wrenches or impact tools where used be recalibrated before each shift.

All fabrication and erection procedures shall be in accordance with B.S. 449 as amended, Part 5. Before commencing the fixing of the steelwork the erector shall check the seating for line, level and bolt setting, and any errors which cannot be accommodated by the steelwork erector shall be reported to the Engineer.

3.25. **STEEL FABRICATION AND BASEPLATES**

The manufacture of all fabricated items of plant shall be generally in accordance with B.S. 449 as amended, Part 5.

The fabrication and manufacture of the plant and equipment shall be completed in the Mechanical Contractor's workshops before delivery to site. No fabrication of complete units shall take place on site, sitework shall be confined to only such minor alterations and adjustments as are found to be necessary during erection. If major alterations are found necessary the items of plant covered shall be returned to the Mechanical Contractor's workshop for modification on replacement and shall be tested and checked before re-delivery to site.

Drive baseplates shall be robustly constructed and adequately stiffened to prevent twisting and distortion. The ration of the base length to its height shall not be more than 10:1.

All surfaces shall be free from recesses and cavities to prevent the accumulation of dirt and/or waste material, and shall be designed to facilitate ease of cleaning and maintenance.
Where driving units are directly coupled to the driven component all mounting surfaces shall be accurately machined to ensure alignment. After final assembly and testing, the individual items of plant shall be accurately dowelled in position on the baseplate to prevent misalignment during installation or during operation.

The Mechanical Contractor shall include in the design for any measures required to counter the effects of vibration which might be caused by operation of equipment.

3.26. STAINLESS STEEL

All items fabricated in stainless steel shall be in the grade specified and detailed designs shall be compatible with fabrication techniques. The designs of articles to be pressed or welded shall be discussed with the fabricator before manufacture. All stainless steel items shall have a 'half-moon' finish to the satisfaction of the Engineer. Edges shall be finished by either welding on 12mm stainless steel round bar in the same grade as the article or by turning down to an acceptable radius.

3.27. WELDING

3.27.1. Welding

Welding shall be carried out in accordance with the BC Code of Practice for welding No.044 Parts 1, 2, 3, & 4.

3.27.2. Freedom from Surface Defects

All welded fillets or butt joints shall be ground smooth and shall be free from porosity, cavities and entrapped slag. All welds shall conform to the requirements of B.S. 1856.

Welds which are to be hot dip zinc coated shall be neatly formed and the surfaces shall be acceptable and free from cracks in the welds or heat affected zone, from overlap undercuts, porosity, entrapped slag and spatter in or associated with the welds. The welds shall seal completely the edges of all overlapping or contacting surfaces.

3.27.3. Smoothness of joints where Weld is re-commenced or terminated

The joints in the weld run where welding has been recommenced or terminated shall be smooth and shall show no pronounced hump or crater in the weld surface.

3.27.4. Shape of Profile

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

3.27.5. Uniformity of Surface

The weld face shall be uniform in appearance through its length.
3.27.6. **Electrodes**

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 the latest issue of B.S. 693 'Electrodes for Manual Metal Arch Welding of Mild Steel and Medium High Tensiles Steel'.

3.27.7. **Qualification of Welders**

Welding on or off the site shall be carried out only by welders qualified to the approval of the Engineer. Each welder to be used on the Mechanical Contract Works will be required to carry to test welds to the approval of the Engineer and in the presence of the Engineer's Representative. Only welders whose test welds have been passed by the Engineer shall be employed on the Mechanical Contract Works and then only for the class of welding for which they have been tested. Initial testing of welders and such periodical tests as may be required by the Engineer shall be carried out at the Mechanical Contractor's expense using materials supplied by the Mechanical Contractor.

3.28. **HOT DIP (Galvanised Zinc Coatings)**

3.28.1. **General**

All hot dip zinc coatings shall conform to the requirements of the latest issue of specification 'Hot-Dip (Galvanised Zinc coatings' with particular reference to the following.

Tubular constructions shall be provided vent holes in appropriate locations to prevent internal pressure build-up during the hot zinc bath shall be referred to the galvaniser who shall state his requirements for the vent holes desired. Welding flux shall be chipped away, all welds shall be wire brushed, ground or grit or shot blasted if necessary before hot zinc coating.

The surfaces to be hot-dip coated shall be free from paint, oil, grease, and similar impurities. Identification numbers of individual pieces shall be clearly stamped on surfaces of members prior to hot-zinc coating, numbers painted or welded on the surfaces of these members shall be unacceptable.

Exposed surfaces, except welds when necessary, need not be grit or shot blasted, but the engineer shall decide to call for grit or shot-blasting in cases of unsuitable surface finish on material for hot-dip zinc coating. The Engineer shall have 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 unsuitable. This applies particularly to welds, burrs, and surfaces having visible surface defects.

Globular extra heavy deposits for zinc which interfere with the intended use of the material shall not be acceptable. Excessively protuberant lumps and nodules shall be removed by hot wiping or skilful application of mechanical means provided that a sufficient minimum thickness of unbroken zinc coating remains after such treatment. Flows on small parts and working surfaces shall be repaired only by stripping, dressing and re-dipping.
3.28.2. **Threads**

The galvanising on threads or bolts shall be such as to fit a gauge made by overtapping a nut to the following increased limits of size to 7H tolerances:

<table>
<thead>
<tr>
<th>Bolt Sizes</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M16</th>
<th>M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcut, mm</td>
<td>To be Agreed</td>
<td>To be Agreed</td>
<td>0.33</td>
<td>0.33</td>
<td>0.38</td>
<td>0.38</td>
</tr>
</tbody>
</table>

For threaded articles less than 10mm diameter mechanical plating will be acceptable instead of hot dip zinc coating (galvanising).

Nuts shall be capable of being spun over the full length of the thread by hand ungalvanised internal threads shall be coated immediately after cutting, before they are allowed to rust, with preventive compound of type agreed between the supplier and the Engineer.

3.28.3. **Bolts**

Bolts to be galvanised shall be standard black bolts manufactured according to B.S 916 (and having threads produced to medium class tolerances G8). Any bolt which has been subjected to cold forming (heading) operation during manufacture shall be stree-relieved at a temperature between 600°C for a minimum period of 20 minutes and subsequently cooled in air.

3.28.4. **Protection of Coating (Passivation)**

Immediately after withdrawal from the bath of molten zinc, galvanised material shall be quenched in water containing approximately 1% of sodium dichromat slightly acidified with sulphuric acid. Other bath compositions may be used provided that they contain recognised passivating agents unless otherwise specified.

Alternatively by agreement between the galvaniser and the Engineer, protection may be applied by other means, such as, for instance, a lacquer containing chromate salts.

3.28.5. **White Rust (White Storage Stain)**

All galvanised material shall be free from gross deposits of white rust. If material has been affected by white rust, the deposit may be removed, by means of non-metallic brushes and provided that the thickness of zinc coating in the affected area meets the requirements of the specification the material can be accepted.

No galvanised material shall be used for erection unless such material:

a) has been zinc coated under the KBS certification scheme, and this is indicated by the diamond standardisation mark, which should appear on all labels, delivery notes, and other similar documents relating to such material. Such documents should also indicate the name of the galvaniser concerned.
Structural material should also bear a paint mark applied by the galvaniser to indicate standardisation mark quality. The Engineer may call for certificates from the galvaniser indicating that each consignment of material complies with the specification and was galvanised under the certification mark scheme: or

b) The galvanised material has been inspected, and each consignment is accompanied by an inspector's certificate indicating that the material is acceptable and complies with the requirements. Structural material should also bear a paint mark applied by the inspector to indicate that the material has been inspected and accepted. Bolts, nuts and other material of small size should be in a bag or container containing a label bearing the inspector's stamp.

3.29. CASTINGS

Because of the corrosion-inducing conditions, and in order to obtain satisfactory mechanical properties of tensile, shear and yield strengths, resistance to impact and transverse loads and hardness properties, all ferrous castings other than those included in the proprietary 'bought out' items of equipment shall comply with the specification hereunder. If the Contractor wishes to offer alternative materials, he shall submit comprehensive details of such alternatives and obtain the prior written approval of the Engineer before proceeding with manufacture.

Material: Pearlitic Nodular Structure.

Mechanical Properties:
- Ultimate Tensile Strength - 725 mpa
- Elongation - 2%
- Hardness - 240 to 300 brinell (after normalizing)

Inoculation: All castings shall be inoculated with 3% copper.

Heat Treatment: To provide the optimum physical properties consistent with the pearlitic nodular structure of the material, and to provide a hardness within the range 207 to 235 brinell.

Test Certificates: The contractor shall submit to the Engineer all test certificates of analysis including all relevant details of the micro-structure and mechanical properties. The number of tests to be performed and for which certificates of analysis are required shall depend on the respective casting and shall be agreed in writing with the Engineer.

3.30. VEE-BELT DRIVES

All vee-belt drives shall conform to B.S. 1440: 1962 - "Endless V-belt drives" and shall be as specified below:

a) Application

Unless otherwise specified or agreed to by the Engineer, Vee-Belt drives shall only be used in applications of constant and slightly varying load conditions. Belt speeds shall not exceed 900 metres per minute, unless otherwise agreed. For reasons of spares interchange ability and maintenance, standard stock vee-belts shall be used.

b) Pulleys
The belt pulleys shall be manufactured from a close-grained cast iron and shall be accurately balanced. The belt grooves shall be properly machined to the correct groove angle and depth.

All sharp corners at the top of the groove shall be removed and the groove sides shall be polished smooth to avoid excessive belt wear. The grooves of mating pulleys shall accurately match each other, particularly regarding width, angle and alignment.

c) Adjustment

Adjustment inward, i.e. towards the driven pulley, shall be provided to ensure sufficient movement of the driving pulley to enable the vee-belts to be fitted by hand, without the use of a lever of any kind to force the belts over the pulleys.

The outward adjustment shall provide for correct belt tensioning to ensure that slipping does not occur. All belt tensions shall be re-checked within 24 hours and again within a week to start-up to ensure that the initial slack, if any, is taken up.

d) Speed Ratio

Speed ratios greater than 7:1 shall not be acceptable unless otherwise agreed by the Engineer.

3.31. BEARINGS

3.31.1. Anti-Friction

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

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

3.31.2. Bushed Bearings

Only where specifically stated and in cases of low velocities and light loads in moisture-free conditions will bushed bearings be accepted. All bushed bearing shall be made of an approved friction quality and shall be capable of withstanding severe usage.

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 surface. Grooves shall not be cut into the journal, but always into the surrounding bush. The edges of all chamfers and grooves shall be rounded to avoid sharp corners and to facilitate the introduction of the oil or grease.
3.31.3. **Self Lubricating or Oil-less Bearings**

Self-lubricating or oil-less bearings shall only be used on application of light loads and low velocities in moisture-free and low humidity conditions and where bearings are of difficult access and likely to be neglected during servicing. The types of bearing metal composition used shall have frictional and wear resistant properties akin to those of grease lubricated bushed bearings.

3.32. **KEYS AND KEY WAYS**

All keys and Keyways and taper pins shall conform to B.S. 46: Part 1, 1958.

3.33. **LIMITS AND FITS**

Limits and tolerances for shafts and hoes shall conform to B.S.3614.

3.34. **GENERAL MACHINERY PROTECTION**

3.34.1. **Coupling and Shaft Guards**

All high speed couplings, projecting shaft ends and every dangerous moving part of machinery shall be protected by a guard manufactured from not less than 1.6mm mild steel plate. The guards shall be neatly formed and securely fixed in position.

3.34.2. **Belt Guards**

All belt or rope drives shall be adequately protected by a belt guard.

The guard shall be manufactured from wire mesh or open type expanded metal, securely braced and stiffened with suitable rolled steel sections and bolted in position. Guard supports shall not short-circuit vibration isolators on form. Provision must be made for test openings to permit RPM reading of fan and motor without the removal of the belt guard.

3.34.3. **Painting**

All guards shall be finished in a light orange colour to B.S. 381C in accordance with Clause 2.8.4 Class 'C'.

3.34.4. **Equipment Bases**

Unless stated elsewhere in this specification, inertia base formers for machinery shall be provided to the Main Contractor for casting, by the Contractor for casting, by the Contractor. The bases shall consist of reinforced concrete cast into sheet metal formers at least 150mm deep.

The formers shall comply with the standard set by Mason Industries, for both size and construction. Bases shall be mounted on properly selected spring isolators incorporating noise isolation pads.

Either free-standing stable steel spring or caged spring with snubber may be used. Spring isolators shall be provided with levelling bolts. Noise isolation pads shall be large enough to prevent excessive rocking of equipment during start up and normal
operation. Bases and supports shall be arranged to give a clearance of approximately 25mm between the underside of the bases and the floor. Bases shall be large enough to accommodate motors and the equipment they drive.

3.35. IDENTIFICATION AND LABELLING

All plant and equipment items, including items such as dampers, pumps, etc, shall be labelled in a clearly visible position with the item name and, in the case of duplicate items, a number. Plant labels shall correspond with labels on starters, isolators, etc.

Labels shall be of sandwich thermosetting plastic with black lettering on a white background. Lettering shall be at least 6mm high and labels shall be in keeping with the size of equipment and legibility with regard to position.

3.36. PAINTING

3.36.1. Painting Materials

All paint shall be non-toxic, driers and the like, and other materials shall conform with the requirements of the relevant British Standard Specification. All paints shall be of the best quality and of approved brand and manufacture. All materials shall be used in strict accordance with the manufacturer's instructions and otherwise in strict accordance with the best standard practice. Undercoats of paintwork and primers shall be as supplied by the manufacturer of the paint begin used for the finishing coat. If necessary, paint shall be strained free from skins and similar impurities immediately before application. Priming coats shall be applied over the whole surface and well brushed in order to obtain the maximum penetration. All materials shall be delivered to the job in their original unopened containers with the manufacturer's name and description of contents thereon and no adulteration will be allowed.

3.36.2. Colours

Samples of the final colours required shall be submitted for approval before painting the work in hand and the work shall then be finished to the colour or colours as approved. Each coat of paint shall be a distinctive colour working up to the finished colour as approved.

3.36.3. External Painting

External painting shall not be undertaken during rainy, damp, frosty or other inclement weather or where such weather is reasonably to be expected within the next 24 hours.

3.36.4. Internal Painting

Before internal painter's work is commenced all floors shall be swept clean, and dirt and rubbish removed, and the rooms left practically free from dust; dust-free conditions being maintained during the progress of the work. No sweeping or dusting shall be done whilst the painting is in progress.

Unless otherwise stated, no paint shall be applied within 50mm of areas which are to be welded. Welds and adjacent parent metal shall be de slagged, inspected and approved and area shall be abrasive blasted or ground, and all contaminants shall be removed prior to painting. Wire brushing of the weld shall only be allowed if the
paint specification calls for wire-brushing. The weld area shall then be flushed with fresh water and allowed to dry before receiving the full paint system.

Areas where the paint coating has been damaged during transportation erection or by any means whatever, shall be repaired as follows:

Damaged areas or rust spots shall be removed by means of a wire brush or emery paper and the surrounding paint which is still intact shall be feathered for a distance of 20mm beyond the damaged area. Spot priming shall consist of all the coats previously applied and shall overlap the undamaged area by 20mm. Surfaces which are to rest on concrete or other floors or which will be inaccessible after erection shall receive full specified paint system before erection or assembly. Unless otherwise specified, steel embedded with concrete shall not be painted except to within 50mm below the concrete/air interface.

Mating or contact surfaces shall be protected from corrosion by ensuring that the two surfaces brought into contact with each other shall be prepared and primed in accordance with the specification. The primed surfaces shall be brought together while the paint is still wet. Surfaces which are to be friction-bolted shall be prepared in accordance with the specification (i.e. blast-cleaned or wire-brushed) but shall receive no paint coating. All sharp edges shall receive the specified dry film thickness of paint.

Where the shop coat has been allowed to age for a few months before painting, it shall be lightly sanded or rubbed with steel wool and scrubbed with clean water using a bristle brush. Before painting galvanised iron surfaces, they shall be treated with galvanised Iron Cleaner or equal and approved cleaner, used in strict accordance with the manufacturer's instructions. Where a temporary protective coating has been applied to prevent wet storage stain, the surface shall be thoroughly scrubbed down by means of a bristle brush and the approved cleaner until all the temporary protection has been removed. The treated surfaces shall then be thoroughly washed down with clean water and the surfaces allowed to dry before painting.

All galvanised sheeting shall be painted on the ground before erection. This will also ensure that overlaps are well protected. Where it is impracticable to apply the coating system before erection, prior consent to paint after erection shall be obtained from the Engineer.

Paint dry-film thickness shall be measured using a non-destructive thickness gauge such as the MIKROTEST or equivalent.

3.36.5. Inspection of Surfaces

All surfaces to be painted shall be carefully inspected by the Contractor who shall satisfy himself that the surfaces are in a perfect state to take the paintwork specified. No claim will be entertained arising from defective work due to not strictly insisting on receiving from defective work due to not strictly insisting on receiving from other trades, surfaces in a proper condition, fit to receive the type of paint specified. All surfaces shall be perfectly clean, free from dust, dirt, grease, blotches, and other blemishes before painting, staining or application of any coat.
All surfaces shall be properly prepared before painting or staining. Each coat of paint, except the last, shall be rubbed down with a fine glass paper before the next coat is applied.

Unless otherwise directed, the last coat of paint or finishing shall be done when all other work in the Contract is completed and the premises free from all rubbish and dirt. On completion, all painter's work shall be touched up where necessary and any defects made good. All paint and stain spots shall be removed and all surfaces left in a perfect condition.

3.36.6. **Iron and Steel Surfaces**

The contractor shall ensure that primed steelwork which is to be delivered to site is stacked on bearers and is clear of the ground. Wherever possible channels, angles, and other equipment and material shall be stacked so that water cannot collect on the steel.

Iron and steel surfaces shall be scrapped or shot blasted to produce a clean surface before painting. Paint shall not be applied over any surface containing traces of grit, grease, oil and the like, loose rust, loose millscale or corrosion products and foreign matter of any kind.

All air used for blast-cleaning or spraying shall be free from all traces of water and oil. When blast-cleaned, a satisfactory blast profile (i.e. anchor pattern) shall be achieved. If the abrasive used for blast-cleaning is sand, it shall be free of clay. All metal surfaces to which paint is to be applied shall be moisture dry paint surfaces which are to be over-coated shall be hard-dry before over-coating, unless otherwise specified.

3.36.7. **Painting of Steel Surfaces with Polyurethane System**

This system is based on a polyurethane which is cured with an Aliphatic Di-Isocyanate. No polyurethane products which are cured with Aromatic Di-Isocyanate curing agents will be acceptable. This system shall be used as specified in highly corrosive conditions and where a high quality finish is required.

a) **In Fabricator's Premises**

i) **Surface Preparation.** All steel surfaces shall be abrasive blast-cleaned to a near-white finish and shall be free from oil and grease and any corrosive contaminants.

ii) **Priming.** Within 4 hours of blast-cleaning, one coat of an approved zinc chromate epoxy primer shall be applied to give a minimum dry film thickness of 38 micrometres.

iii) **Undercoat.** One coat of an approved undercoat compatible with both the primer and the finishing coat to give a minimum dry film thickness of 50 micrometres

b) **On Site Painting**

After erection the following procedures shall be adopted:-

i) Damaged areas shall be repaired as per clause 15.4 above, and spot priming shall comprise all the shop coats.
ii) **Undercoat.** Unless the undercoat has already been applied it shall be applied before erection as described in Sub-Clause (a) iii) above.

iii) **Finishing.** Two finishing coats of approved polyurethane enamel in the specified colour shall be applied to give a minimum dry film thickness of 25 micrometres per coat. The two coats shall be distributable in colour and the second coat shall be applied within 24 hours of the first. The total Minimum dry film thickness for the complete paint system shall be 138 micrometres.

### 3.36.8. Painting of Steel Surfaces with Alkyd System

This system shall be used as specified on columns, roof trusses, steel window frames and door jamb, pipes, pumps and equipment in areas where corrosion is mild and a decorative appearance is required.

i) **Surface.**

Where a decorative rather than corrosive resistant finish is required, steel surfaces may be specified to be mechanically or hand wire brushed to remove loose rust millscale.

Where a more corrosive resistant finish than the above is specified, all steel surfaces shall be abrasive blast-cleaned to a near white finish. The abrasive shall be free from oil and grease and corrosive contaminants such as chlorides and the like.

ii) **Etch Priming.** (Applicable to abrasive-blasted surfaces only).

Within 24 hours of cleaning, apply one coat of an approved single pack within 4 hours of cleaning, apply one coat of an approved single pack zinc chromate etch primer to give a dry film thickness of not less than 20 micrometres.

iii) **Priming.** (For abrasive - blasted surfaces).

Apply one coat of an approved zinc chromate primer (green) to give a dry film thickness of not less than 38 micrometres.

For wire brushed surfaces to the clean steel apply one coat, by rush or roller, of an approved red lead primer to give a dry film thickness of not less than 38 micrometres.

b) **On-Site Painting of Steelwork**

i) **Damaged Areas**

Before and after erection damaged areas shall be repainted as for Clause 15.4 above, and spot priming shall comprise all the shop coats.

ii) **Undercoat**

Apply one coat of an approved undercoat to give a minimum dry film thickness of 38 micrometres. The undercoat may be tinted to a shade just lighter than the finishing colour using approved stainers.

iii) **Finishing**
Apply at least one coat of an approved high gloss enamel in the specified colour, to give a minimum dry film thickness of 25 micrometres.

The total dry film thickness for the complete system shall not be less than 100 micrometres for wire-brushed surfaces, and 120 micrometres. The total dry film thickness for the complete system shall not be less than 100 micrometres for wire-brush surfaces and 120 micrometres for abrasive-blasted surfaces.

**Note:** Where window frames, door jambs and the like have been painted in the fabricator's yard with red oxide primer, this shall be rubbed down and primed in accordance with Clause 15.7 (a) III.

c) Painting of Motors, Gear Boxes and other Equipment

i) **Surface Preparation**

   The surfaces to be painted shall be completely free from oil, grease, rust and foreign matter of any kind.

ii) **Priming**

   One coat of an approved epoxy primer shall be applied to form a uniform coat and to fill all porosities in the castings. After 24 hours the primer shall be wet sanded to produce a uniform smooth surface.

iii) **Undercoat**

   One coat of suitable undercoat tinted to a shade just lighter than the finishing colour with suitable staining agent, which is compatible with the paints, shall be applied.

iv) **Finishing**

   One coat of approved high gloss enamel in the specified colour shall be applied. N.B. Flanged faces shall receive the full specified coating.

d) Painting of Pipes

i) **Surface Preparation**

   The surfaces shall be wire brushed to remove loose rust and loose millscale.

ii) **Priming**

   An approved one coat primer shall be applied.
iii) **Undercoat**

Undercoat shall be specified in Clause 15.8.

iv) **Finishing**

The finishing coat shall be as specified in Clause 15.8 (c) (iv). The total dry film thickness for the coating system shall not be less than 90 micrometres. N.B. Flanged faces shall receive the full specified coating.

3.36.9. **Painting of Galvanised Surfaces with Alkyd System**

This paint system shall be used as specified for painting of side sheeting, ducting and plenum walls, underside of roof sheeting and the outside surfaces of rain water gutters where a decorative effect is required. It shall only be used where the corrosive conditions are mild.

i) **Surface Preparation**

The surfaces shall be prepared in the manner as described in Clause 15.4 above.

ii) **Priming**

To the cleaned surfaces apply one coat of an approved Calcium Plumbate primer.

iii) **Undercoat**

Apply one coat of approved high gloss enamel in the specified colour. The total paint dry film thickness for the system shall not be less than 100 micrometres.

3.36.10. **Painting of Equipment and Steelwork with Epoxy System**

i) **Surface Preparation**

a) **Equipment**

Where the equipment is specified to be painted after installation it shall be delivered to site unpainted. The surfaces to be painted shall be completely free from oil, grease, rust and all other foreign matter. If possible, castings shall be fettled prior to priming.

b) **Supports and Steelwork**

All surfaces shall be abrasive blast-cleaned. The abrasive shall be free from oil, grease, and corrosive contaminants such as chlorides and the like.

ii) **Priming**

Apply one coat of approved epoxy primer to form a uniform coat, and to fill all porosities in the casting. After 24 hours the primer shall be wet sanded to produce a uniform, smooth surfaces.

iii) **Finishing**
Apply two coats of an approved Epoxy Enamel in the specified colour, the second coat to be applied within 24 hours of the first. N.B. Flanged faces shall receive the full specified coating system.

3.36.11. **Painting of Galvanised Surfaces with Epoxy System**

This paint system shall be used for painting of galvanised surfaces in highly corrosive conditions.

i) **Surface Preparation**

These surfaces shall be prepared in the manner as described in Clause 15.4 above.

ii) **Priming**

To the cleaned surfaces apply one coat of approved Epoxy Zinc Chromate Primer.

iii) **Finishing**

Apply two coats of approved epoxy enamel. The second finishing coat shall be applied within 24 hours after the application of the first finishing coat, and shall be distinguishable in colour from the first. The total minimum dry film thickness for the paint system shall be 88mm.

3.36.12. **Painting of Chequer Plate of Egg-Crate Flooring and Supporting Frames with Epoxy Tar System**

This paint system shall be abrasive blasted or acid pickled and passiveated.

i) **Surface Preparation**

Surfaces shall be abrasive or acid and passivated.

ii) **Finishing**

Three coats of approved epoxy Tar shall be applied. Consecutive coats shall be in distinguishing colours.

3.36.13. **Painting of Galvanised Surfaces with Epoxy Tar System**

This paint system shall be used for the painting of internal surfaces of galvanised gutters.

i) **Surface Preparation shall be described in Clause 15.4**

ii) **Finishing**

To the cleaned surfaces apply one coat of approved Calcium Plumbate Primer.
iii) **Undercoat**

Apply one coat of suitable undercoat tinted to a shade just lighter than the finishing colour with a suitable tinting agent which shall be compatible with the paint.

iv) **Finishing**

The Contractor shall apply two coats of approved Epoxy Tar. The second coat shall be applied within 24 hours of the first coat. The total paint dry film thickness shall be not less than 200 micrometres.

3.36.14. **Painting of Steelwork with Chlorinated Rubber System**

This system shall be used in areas where the steelwork is exposed to occasional corrosive conditions.

a) **In Fabricator's Yard**

i) **Surface Preparation**

Abrasive blast-clean all steel surfaces. The abrasive shall be free from oil, grease and any corrosive contaminants.

ii) **Priming**

One coat of approved chlorinated rubber undercoat shall be applied to give minimum dry film thickness of 75 micrometres.

iii) **Undercoat**

One coat of approved chlorinated Rubber Undercoat shall be applied to give a minimum dry film thickness of 75 micrometres.

b) **On-Site Painting**

After erection, the following procedure shall be adopted:

i) Damaged areas shall be repaired as described in clause 15, 4 above and spot priming shall comprise all the shop coats.

ii) **Finishing**

One coat of approved chlorinated rubber enamel shall be applied in the specified colour, to give a dry film thickness of not less than 25mm.

3.36.15. **Painting of Galvanised Surfaces with Micaceous Iron Oxide Pigmented Alkyd System**

Unless the Engineer has given his written consent, the galvanised sheets shall be primed on the ground before erection.

i) **Surface Preparation.** The surfaces shall be prepared in the manner as described in Clause 1.15.4.
ii) **Priming** To the clean surfaces apply one coat of an approved calcium plumbate primer.

iii) **Undercoat.** Apply one coat of an approved Alkyd micaceous Iron Oxide structural paint.

iv) **Finishing.** Apply one coat of an approved Alkyd micaceous Iron Oxide structural paint in colour as specified.

(v) **Damaged Areas** These shall be repaired in a manner as described in clause 1.15.4

The total paint dry film thickness shall not be less than 114 micrometres.

3.36.16. **Specialised Painter**

All painting shall be carried out by a painting specialist employed by the contractor.

### 3.37. PROTECTION OF UNPAINTED SURFACES

**Bright Machined Parts**

All bright machined parts shall have a protective treatment applied by the manufacturer before despatch and this treatment shall be kept intact up to the time of handover unless it has been removed for installation. If the surface is exposed after installation a further protective coating shall be applied in accordance with the manufacturer's requirements.

### 3.38. PIPING AND FITTINGS

3.38.1. **Materials**

Pipework shall be run as shown on the contract drawings. All piping used in the construction of the works shall be straight, cleanly finished, round in cross-section, free from cracks, surface flows, laminations and other defects and free from scale.

3.38.2. **Neatness**

All pipe runs shall be arranged to present a neat appearance with where practicable shall be parallel both with one another and with the building structure, paying due regard however to the grading and venting requirements. All vertical pipes shall be plumb.

Pipes shall be bent round piers and all other projections and recesses and all offsets due to varying thicknesses of plaster, walls, floors and ceilings and other structural works were such changes in direction of piping are indicated on the drawings or not. Details of the skirting heights, sill heights and floor finishes shall be determined before any work is commenced. No pipework offsets shall be allowed on piping.
3.38.3. **Prevention of Dirt Entering Pipes, valves etc.**

All pipes, fittings, valves, etc. shall be guaranteed to be free from corrosion and internal obstruction. Pipes and fittings showing signs of corrosion shall not be fitted.

The open ends of all pipework and valves shall be protected. Wrought-iron screwed caps or plugs or plastic covers only shall be used to cover open ends. Wood, rag or paper plugs shall be used. Pipework delivered for use on the Contract Works shall be stored clear off the ground on suitable racks or stands and with the ends protected as described above.

3.38.4. **Pipe Cutting and Cleaning**

All cuts from Standard lengths of pipe shall have all burrs and swarf removed, the ends shall be trimmed square and the pipe shall be thoroughly cleaned both internally and externally before erection.

3.38.5. **Accessibility**

All valves, drains and supports shall be positioned so as to facilitate maintenance. Grouping of valves, drains union’s flanges etc. shall be preferred to scatted siting. Joints shall not be formed in the thickness of walls, floors or ceilings. All pipework, valves fittings and equipment forming the piping installation shall be erected so that it can be dismantled and be readily accessible for repair and replacement.

Readily accessible means that the flange, union, etc., can be reached and worked upon either in the open or else by removal of a purpose made duct cover, manhole or similar cover. The fitting is not accessible if as fixed it cannot be manipulated.

Where pipework is to be installed in an inaccessible position it shall be welded or brazed. Unions or flanges shall be provided as equipment to facilitate dismantling. Care shall be taken to ensure that pipe flanges, valves etc. are staggered relative to similar projections or adjacent pipes and obstructions such as bemas columns and pipe supports, where necessary.

3.38.6. **Grading of Pipework**

All pipework shall be installed with continuous gradients to allow for drainage and for venting air. The rise or fall of piping in the direction of flow shall be as laid out in the schedule below (unless noted otherwise on the drawings or instructed by the Engineer.

<table>
<thead>
<tr>
<th>Service</th>
<th>Rise or Fall</th>
<th>Minimum Gradient mm per meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Rise (preferred)</td>
<td>2</td>
</tr>
<tr>
<td>Steam</td>
<td>fall</td>
<td>4</td>
</tr>
<tr>
<td>Condensate</td>
<td>fall</td>
<td>4</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>fall</td>
<td>8</td>
</tr>
</tbody>
</table>

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3.38.7. Pipes laid in Ground

Pipes laid in the ground shall be assembled with care and shall be well bedded in to ensure that pipework and fittings shall not be damaged by movement of the ground. (Steel pipes shall either be supplied with factory applied bitumen/fibreglass wrapping and joints site-wrapped with bitumen tape, or the entire pipeline shall be primed with Densopaste, protected with Denso tape applied with a 55% overlay and protected with PVC wrapping securely fixed).

Excavation in ground and backfilling of trenches with sealed backfill shall be by others unless specified otherwise.

3.38.8. Pipes Joints

a) Types of Joints

Joints shall be screwed, welded or flanged as specified for each particular service elsewhere in this specification. Joints shall comply with relevant KBS or BS specification. All flanges shall be at 90° to the centre line of the pipe and the holes shall straddle the centre line.

b) Screwed Joints

Pipes for screwed joints shall be provided with taper threads to B.S. 21 Part 1. Steel pipes shall be carefully reamed out before the plain end is threaded. Threads shall be right, clean and free of burrs prior to installation. Before making a joint, the male screw thread shall be wrapped with Polytetrafluoroethene (PTFE) tape. Alternative jointing compounds shall not be used without the express approval of the Engineer.

Should a screwed joint prove defective under test or in operation, the joint shall be broken and remade, caulking will be permitted.

c) Flanged Joints - Steel Pipes

All flanges, bolts, nuts and washers shall be manufactured from mild or stainless steel to B.S. 4504 Part 2 "Table of Piped Flanges (for land use)" to the table appropriate to the pressure specified. Bolt holes in flanges shall be drilled, not punched, and spot faced for nuts.

Pipes not galvanised shall be provided with flanges crewed or welded for nominal bores of 80mm and below and with welded flanges for larger sizes. Galvanised pipes shall be provided with galvanised screwed flanges for nominal bores 80mm and below and with welded flanges for larger sizes. For galvanised piping all welding shall be carried out before galvanising.

Welded flanges shall be of the machine-faced, slip-on pattern with neck secured by welding both at the neck and bore of the flange to pipe, with the pipe finishing 3mm inside the bore. Care shall be taken not to distort the machined face. The use of alternative flanging to the ASA standards throughout the installation will be considered upon application.
d) Flanged joints - Polypropylene Pipe

Flanges on polypropylene pipes shall be of the full face type up to and including 100mm NB, and the stub flange type with mild steel backing ring for sizes 125mm NB and above, these shall also be used on sizes below 100 mm NB upon the Engineer's request.

All drilling in flanges and backing rings shall be to B.S. 4504 Part 2 "Table of Pipe Flanges" (for land use) and the holes shall be drilled, not punched, and spot faced.

Thickness of flanges and backing rings shall be as specified for each service and the material for the flanges and stub flanges shall be identical to that of the pipe. The use of the alternative flanging to ASA standards throughout the installation will be considered upon application.

e) Gaskets and Bolts

The joint between flanges shall be made up with a joint ring graphite faced on both sides. Joint strings shall be suitable for the pipeline pressure and temperature duty and shall be identified for duty for which they are suitable. Joint rings shall be cut from sheets on site.

Bolts heads and nuts shall be hexagonal in form and washers shall be fitted beneath bolt heads and nuts. The lengths of bolts shall be such that not less than one thread nor more than 5mm of bolt protrudes through each nut when the joint is pulled up. All bolts and nuts shall be corrosion resistant.

f) Welded Joints - General

Welding technique, edge preparation and welding rods or electrodes shall be selected to be suitable in all respects for the materials and duty of the pipeline, and comply with the applicable British Standards.

Each approved welder will be assigned a reference number which shall be stamped on each weld carried out by him. During the progress of the site work ultrasonic or radiographic examination or welds may be carried out by an independent authority at the expense of the Employer. Welds found to be defective shall be cut out and the pipe made good, all the contractor at his own expense, and the new welds retested at the contractor's expense.

The Contractor shall cut out and prepare for mechanical testing in the presence of the Engineer, welded joints selected by the Engineer. Cutting out and preparing of test pieces and the making good of pipelines shall be at the contractor's expenses. The total number of such tests will not exceed one per cent of welded joints except that welds found to be defective shall not form part of this total.

Should a significant proportion of the tested welds of a particular welder prove to be defective due to faulty workmanship, all welds carried out by the particular welder shall be cut out and the pipeline made good by another welder whose work has proved satisfactory.

When the general hydraulic test of the completed systems is carried out, each weld shall be lightly hammered during the time pressure is maintained. If any leaks occur
at welds, the portion of weld near the leak shall be removed by cutting or grinding and welded. Repairs shall not be attempted by caulking or fusion of surrounding metal.

g) **Welded Joints - Steel Pipes**

Oxy-acetylene welding shall generally be carried out in accordance with the "Recommended practise of oxy-acetylene welds in mild steel pipelines" publishing by the Heating and Ventilation Contractors Association. Metal arc welding shall be in accordance with Technical Memorandum T.3 issued by the British Welding Research Association.

The contractor shall obtain from the manufacturers tests certificates representative of welding rods and electrodes used and in accordance with B.S. 1453 or B.S. 639 respectively.

All welded joints, whether produced by oxy-acetylene flame or metal are processes shall be of prime quality. The butts shall be slightly convex with regular ripples and no undercutting, washing away or surface cavities shall be present. Notches at the root into the pipe bore in excess of 1.5mm will be accepted and the external reinforcement shall run out smoothly to the pipe surface on either side. All slag shall be removed after each run. Undercut edges, slag pockets, unsound metal and blowholes shall be chipped out as the work proceeds.

h) **Welding - Polypropylene**

The use of radial welding equipment for pipework joints shall be preferred. The butt machine used for the welding of polypropylene pipes shall be of a design approved by the Engineer. The machine is to carry out the butt welding of pipes from 100 mm NB up to and including 300 mm NB, must be capable of welding flanges and fittings onto the pipe, and be able to do angular butt welds for development of special bends.

The machine shall be capable of maintaining a welding force of 3500 N. The welding force to be maintained at each weld shall be 10N for each square centimetre of annular pipe surface, at a temperature of 250 plus or minus 10°C, and therefore provision shall be made for the heating of both mating surfaces to a temperature of, and maintaining, 250 plus of minus 10°C. All heating surfaces in contact with the piping material shall be Teflon coated.

i) **Pipe Fittings**

**General**

Fittings shall be to the standards specified elsewhere in this specification and shall be compatible in all respects with the materials and class of piping being installed. Where standard fittings are not available for the duty required, reductions on the run and to the branch shall be in all cases be made with reducing sockets reducing bushes and long screw connectors with backnuts shall not be used.

Bends shall preferably be of the long radius type except for the compressed air system and where space is restricted. In these cases short radius elbows may be used subject to the approval of the Engineer.
In general standard tees shall be used for all connections to pipes and headers. The welding on of sockets or branch pipes will be permitted only with the authority of the Engineer. Reducers shall be of the eccentric type, except on vertical pipelines where concentric reducers may be used. Transitions shall be swept and not abrupt. All connections to plant items shall be so arranged that the plat can be easily disconnected. All steam, compressed air and water connections shall be made to the top of the line unless noted otherwise on the drawings.

3.38.9. **Pipe Supports and Guides**

a) **General**

All supports, brackets, hangers clips and other fixing accessories necessary to support all piping system from the building structure or concrete bearers shall be provided and fixed under this Contract. As far as practicable standard bought dip galvanised components shall be used. Samples of these components shall be submitted for approval prior to the placing of order.

Steam and other pipes for high temperature duties be supported on rollers and guided with rollers at changes of direction or other points where necessary to prevent pipes leaving the supports, or on hangers with spherical washers or suitably articulated to take up movement.

Brackets and supporting frames of rolled steel sections shall be fabricated in accordance with the best accepted practice to form true, rigid, neat structures. Makeshift, untidy or unstable supports will be acceptable. Woodscrews, pop-rivets, self-tapping screws, or other fastenings subject to loosening by vibration shall not be used in the fabrication or attachment of pipe supports or fixings. Spring washers, lock nuts or other locking devices shall be used on nuts. Contact between dissimilar metals shall be avoided. A pipe shall not be supported from another pipe unless approved by the Engineer or specifically called for on the drawings. Where a common hanger is used for more than one pipe, provision shall be made to accommodate unequal expansion.

b) **Fixing to Structure**

Fixing to the building structure shall not be carried out in any manner other than that specifically approved by the Engineer for the particular area of the building and type of finish. Care shall be taken to avoid unnecessary damage to finishing.

Competent labour shall be employed to ensure that supports are correctly sized, spaced and set out prior to fixing. All work shall be made good to the Engineer's approval.

For fixing to brick and concrete, holes of correct size shall be neatly drilled using special purpose twist drills, and fixings made by rowl-bolts or equal or bolts of the grouted type approved by the Engineer. Shot fixings shall not be used nor shall fixings be made into mortar between bricks. Fixing to lightweight or hollow structures shall be by means of suitable screw anchors, toggle bolts or approved alternative.
c) **Spacing of Supports**

Spacing of supports for steel and copper pipes shall not exceed the centres given in the following table:

**MAXIMUM SPACING OF SUPPORTS (M)**

<table>
<thead>
<tr>
<th>Nominal Bore of pipe (mm)</th>
<th>Steel Pipes</th>
<th>Copper Pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal</td>
<td>Horizontal</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Vertical</td>
</tr>
<tr>
<td>15</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>20</td>
<td>2.4</td>
<td>3.0</td>
</tr>
<tr>
<td>25</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>32</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>35</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>40</td>
<td>3.4</td>
<td>4.0</td>
</tr>
<tr>
<td>50</td>
<td>3.7</td>
<td>4.5</td>
</tr>
<tr>
<td>65</td>
<td>3.7</td>
<td>5.0</td>
</tr>
<tr>
<td>80</td>
<td>4.1</td>
<td>5.0</td>
</tr>
<tr>
<td>100</td>
<td>4.4</td>
<td>5.0</td>
</tr>
<tr>
<td>125</td>
<td>4.4</td>
<td>5.5</td>
</tr>
<tr>
<td>150</td>
<td>4.8</td>
<td>6.0</td>
</tr>
<tr>
<td>200</td>
<td>5.1</td>
<td>6.3</td>
</tr>
<tr>
<td>250</td>
<td>5.8</td>
<td>6.5</td>
</tr>
<tr>
<td>300</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>and over</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Special supports shall be provided for all heavy items of pipeline equipment such as stainers, valves, etc.

d) **Positions of Supports**

Supports shall be positioned to reduce, as afar as possible, stress on joints, valves and items of equipment. Due to regard shall be given to the maintenance of accessibility and to the requirements of access to their services to be fixed in the area. Vertical pipes shall be supported at the bottom of the riser, or at an intermediate anchor point, to allow for expansion and to carry the entire weight of the riser. Intermediate supports will act as guides. Branches from risers shall not act as supports for the riser.

e) **Guides**

Guides shall be provided and fixed to prevent pipes leaving their supports due to expansion compensating devices.
f) Anchor Points

Anchor points shall be provided to resist the axial stress transmitted by the flexure of expansion loops or bellows. Anchors shall be provided complete for attachment to the structure and where applicable shall be bolted or welded to the structure or positioned accurately for grouting in by others.

On steel pipelines anchors shall consist of heavy mild steel saddles welded all round to the pipe surface and provided with exterior lugs for bolting to the building structure or thrust block. Saddles shall be not less than the thickness of the pipe to which they are welded and of width equal to its nominal bore. On polypropylene pipelines shall consist of 3mm thick polyethylene pads completely surrounding the pipe and then attached to the supporting steelwork with U Bolts. Alternatively, anchors may consist of slip on flanges welded to the pipe and not bolted or welded in the approved manner to rolled steel members attached to the structure.

In the case of copper pipes, anchors shall generally consist of two flanges-to-copper adaptors interposed into the pipe run at the anchor point. Mild steel sections shall be bolted to either side of the flanged joint and attached to the building structure.

3.38.10. Provision for Expansion in Piping

Piping shall be installed in such a manner as to allow for thermal expansion. Where sufficient flexibility is not provided by changes of direction in the run, expansion loops or expansion compensators shall be provided. In general, fabricated expansion loops shall be used to allow 'nesting' of loops in adjacent pipes but purpose made expansion loops may be used if they are suitable for the pressure and expansion duty.

Expansion compensators shall be used only on Engineer's approval and then must be suitable for the working conditions and installed in full compliance with the manufacturer's recommendations regarding guiding, alignment and all other respects of erection and commissioning.

Care shall be taken that the compensators are not overstressed during pressure testing of pipelines, and if necessary, made-up spool-pieces of pipe shall be substituted during these tests.

All supports shall provide for the expansion movement in pipes. Hangers shall be free to 'swing' and rigid supports shall be of the roller type or pipes shall have 'slides' of rolled steel sections welded to them to permit free movement on supports without damage to the pipe or insulation.

3.38.11. Pipe Sleeves

a) General

Pipes shall not be build rigidly into walls, floors, ceilings, footings or under roads. Sleeves shall be provided under this contract, unless noted otherwise on the drawings, for building-in by others at all such locations.

The Contractor shall provide all sleeves in advance of building requirements and shall be responsible for ensuring that sleeves are properly positioned, aligned and built-in. Rectangular or circular openings will be provided by the builder in structural concrete.
slabs and it shall be the Contractor's responsibility to supply, position, align and secure sleeves, ready for casting in by the builder. Puddle flanges shall be provided for building-in where pipes pass through bound walls or below ground.

b) Sizes

Sleeves shall not be used as pipe supports and a free annular space of at least 6mm shall be allowed between a pipe and its covering, if any and its sleeve. In load bearing walls or footings the annular space shall be of a minimum of 25mm. Where pipes change direction, sleeves shall be oversized to accommodate expansion movement of the pipe.

Sleeves shall extend through walls to within 5mm of the finished surface on both sides to allow for flush caulking over the sleeve with water proofing compound. Vertical sleeves shall be project 50mm above the finished floor level and end 5mm above the underside of the slab. Polystyrene or similar material spacer discs shall be provided to locate the sleeve during casting of concrete, so that when the discs are removed the caulking clearance is left.

c) Materials

Sleeves in load-bearing walls and under roads shall be of cast-iron. Other sleeves shall be of standard galvanised pipe cut to length. Sleeves shall properly cut, reamed and trimmed square. Sleeves for casting in the concrete shall be securely fixed to form work by the contractor before concrete is poured. The annular space between each pipe and sleeve shall be firmly caulked at each end with polysulphide or equal waterproof compound which does not set hard.

3.38.12. Ventilation and Draining of Pipework

a) General

Sufficient provision shall be made at high points of piping and equipment for ventilation and at low points for draining. Drains shall be provided on all major sections of pipework so that they can be drained without draining the entire system vents shall be adequate to ensure that airlocks cannot form in the system.

b) Manual Vents

Manually operated air release points shall be provided on all water piping to permit the initial charging of the system. Each point shall comprise an air bottle fitted on tope of the pipe and with a welded cap and 15mm discharge pipe run to a fullway air-release valve at hand level and then to discharge at an agreed point. Pipes up to 40mm shall have air bottles of the same diameter as the pipe, air bottles for larger pipes shall be 40mm diameter. All air bottles shall be 300mm long.

c) Automatic Vents

Automatic vents shall be provided with lockshield isolating valves and 15mm discharge pipes run to approved positions. Automatic vents shall be as equal and approved. Steam mains shall be provided with thermostatically operated air vents at all high points in the system to allow for quick warming up of the system after a shutdown.

d) Drain Points
Steam lines shall be provided with steam trapped condensate drain points at all low points at least every 40 meters on long lines. Drain pockets of diameter equal to that of the steam pipe shall be provided on lines up to 100mm diameter and of diameter 50mm less than the pipe diameter for pipes above 100mm. The condensate line from the trap shall enter the top of the condensate in the header or main.

Water lines and equipment shall be drainable through 15mm lockshield isolating valves and discharge pipes run to approved positions. Compressed air lines shall have trapped automatic condensate drains at all low points in the system.

3.38.13. Valves and Strainers

a) General

Valves and strainers shall be of the types specified elsewhere in this specification, of best quality and suitable in all respects for the duties for which they are intended.

b) Valves

Except where loose key or lever operation is specified, all manual valves shall be provided with handweels. Closing shall be by clockwise rotation of the handwheel. All valves shall conform to the following design and materials specification:

Bronze B.S. 1400 LG-2C or A.S.T.M.B. 62-63
Cast Iron B.S. 1452 GR14C or A.S.T.M.A. 445-63T
Ductile Iron B.S. 1504-161A or A.S.T.M.A. 216 Grade WCB.

Mixing, thermostatic and other automatic valves shall be of 'fail-safe' design and where practicable self-acting.

3.38.14. Pressure Reducing Valve Sets

Pressure reducing valves shall be as equal and approved. They shall be installed complete with separator, isolating valves, strainer, pressure gauges, by-pass and control valves, etc and a pressure relief valve mounted on the low pressure side, sized in accordance with accepted practice, to fully protect any equipment in the event of failure of the pressure reducing valve. The relief valve shall be set, and all gauges shall be in place before steam is allowed to pass through any P.R.V. set. The discharge pipe from the pressure relief valve shall be run to the nearest drain point approved by the Engineer.

3.38.15. Instruments and Gauges - Pipework

Where shown on the drawings pressure gauges and thermometers shall be provided. Pressure gauges shall be of the dial type with minimum 100mm dials and scaled to 50% in excess of maximum anticipated pressure.

They shall be fitted with isolating valves, gauge cocks and syphon bends and installed on extension pipes extended to a convenient position and properly supported. Gauges shall be tested against a deadweight tester in the presence of the Engineer and shall be accurate to within 2% over the working range. Pressure gauges shall be calibrated in kpa. Blow off holes in gauges shall be aimed in a safe direction, away from the
operator. Thermometers shall be of brass mercury-in-glass type at least 150mm long and installed in thermometer pockets so that they may be removed without draining the pipeline. Angle or staring pattern thermometers as appropriate shall be used. Calibration shall be in °C.

3.38.16. Identification and Labelling

a) Pipework

All pipework, both insulated and uninsulated shall have coloured identification band and direction arrows marked on in clearly visible positions at maximum spacings of 6 meters on all runs. This spacing shall be reduced if necessary to ensure that each pipe and branch-passing through any form of space is coded, each branch has at least one coding band and there shall be a coding band within one meter of each valve, plant connections and flange or union.

The colours to be used for banding and arrows shall be agreed with the Engineer but shall comply as far as is possible with B.S. Bands and arrows shall be neatly stencilled using paint system compatible with the surfaces to which they are to be applied. Bands will consist of a base colour band and identification bands of contrasting colours and each 50mm wide.

All insulated pipework other than stainless steel, copper galvanised and polypropylene, shall be painted over the entire length prior to insulating with an approved anti-corrosive inert bituminous based paint, suitable for use on steam pipework. All other pipework shall be painted and code banded, as indicated elsewhere in this specification. On bare polypropylene, identification and direction of flow arrows shall be made by the use of coloured adhesive tape (of a type approved by the Engineer) banded around the pipe in accordance with the foregoing positions.

b) Equipment Items

All plant and equipment items shall be labelled in a clearly visible position with the items name and, in the case of duplicate items, a number. Plant labels shall correspond with designations on the drawings. Labels shall be of rear engraved and filled "trefoiled" of sandwich thermosetting plastic with black lettering on white background. Lettering size shall be at least 6mm.

c) Valves

Section isolating valves and valves in service areas shall be labelled to identify the zones they serve and with an abbreviated code to identify the service. A schedule of labels required will be provided by the Engineer.

Valve labels shall be sandwich thermosetting plastic with black lettering on a white background secured to the valve stem with a light chain. Sample labels shall be submitted for approval.
3.39. PIPEWORK SYSTEM MATERIALS

3.39.1. General

All materials shall be suitable for the temperature rating of the system in which they are installed. These ratings are given in the detailed specification.

3.39.2. Steam Reticulation and Condensate Return

a) Piping

150 mm and below B.S. 1387, heavy class seamless, plain ends prepared for welding.
above 150 mm B.S. 3601/22 or AP1 5.L Sch 20 with wall thickness 6.35mm min.

b) Fittings

Steel butt-weld fittings to B.S. 1640 or equal, wall thickness not less than pipe thickness.

c) Flanges

B.S. 4504

d) Valves

Steam Isolating Valves

Upto to 40mm globe valves with cast bronze or ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and screwed by B.S. 21.

50mm to 150mm globe valves with cast bronze or ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and flanged to B.S. 4504.

200mm and above globe valves with cast bronze or ductile iron bodies, valves with cast iron or ductile iron bodies replaceable seat, bronze or stainless trim, rising spindle pattern and flanged to B.S. 4504.

Steam Regulating Valves

These valves shall be needle valves of materials specification similar to isolating globe valves.

Condensate Valves

Upto to 40mm Cast bronze of ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and screwed by B.S. 21.

50mm to 150mm Cast iron or ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and flanged to B.S. 4504.
Gate Valves

Upto to 40mm ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and screwed by B.S. 21.

Non return valves

Upto to 40mm bronze swing check screwed to B.S. 21.

50mm to 150mm ductile iron bodies, replaceable seat, bronze or stainless steel trim, union bonnet pattern and flanged to B.S. 4504.

Sight Glasses

Bronze/Gunmetal bodies, single window combined sight-check valves may be used only where installed safe from Mechanical damage.

Steam Traps

For line draining Inverted bucket steam trap (stainless steel trim).

For equipment Ball float steam trap to correct pressure range or equal, unless otherwise specified on the drawings. (Stainless steel trim)

Air vents

Thermostatic vent depending on pressure.

Pressure Reducing Valves

Diaphragm pilot operated reducing valve. Stainless steel trim, phosphor bronze diaphragm, correctly sized for flow rate and with high turn-down accuracy and tight shut-off.

Strainers

up to 50mm Malleable or cast iron body, stainless steel screen and screwed connections to B.S. 21

65mm and above Cast Iron or S.G. iron body, stainless steel screen and fanged connections

3.39.3. Cold and warm 45°C Water Reticulation

a) Piping

Piping - Steel

up to 150mm Galvanised steel piping to B.S. 1387, medium class, screwed and socketed.

above 150mm B.S. 3601/22 or API equivalent, 4.5mm wall thickness with plain ends for welding. To be hot dip galvanised after fabricating.

Piping - Polypylene

up to 25 mm 1 500 kpa rated. Extruded from polypropylene - ethylene grade and shall be heat and U.V. stabilised to B.S. 4991 or ISOR 160.
32mm and above 600 kpa rated for cold water and 900 kpa for warm water. Extruded from propylene acetylene and shall be heat and U.V. stabilised to B.S. 4991 or ISOR 160.

b) **Fittings**

**Fittings - Steel**

up to 100mm Fusion welded and of exactly the same material as the polypropylene piping.

above 125mm butt welded or fusion welded and of exactly the same material as the polypropylene piping.

**Fittings - Polyprolene**

up to 150mm Galvanised malleable iron fitting.

above 125mm flanged to B.S. 4504. Fabricated or forged steel.

c) **Flanges**

**Flanges - Steel**

50mm to 150mm B.S. 4504 screwed and galvanised.

above 125 mm Butt welded or fusion welded and of exactly the same material as the polypropylene piping.

**Flanges - Polypropylene**

Full face polypropylene or polypropylene stub flanges with mild steel backing rings drilled to B.S. 4504.

d) **Gaskets**

6mm rubber insertion.

e) **Valves**

**Globe**

Upto to 40mm bronze body, bronze or stainless steel trim, replaceable seating, and screwed to B.S. 21.

65 and above cast iron body, bronze or stainless steel trim, replaceable seating flanged to B.S. 4504.

**Gate**

Upto to 40mm bronze body, bronze or stainless steel trim, replaceable seating, and screwed to B.S. 21.

65mm and above cast iron body, bronze or stainless steel trim, replaceable seating flanged to B.S. 4504.

**Check-valves**

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Upto to 40mm bronze body, bronze or stainless steel trim, replaceable seating, and screwed to B.S. 21.

65 and above cast iron body, bronze or stainless steel trim, replaceable seating flanged to B.S. 4504.

**Ball valves**

Upto to 50mm chrome plated brass, teflon seat rings screwed to B.S. 21, with fixed operating handle.

**Restrictor Valves**

Ball stop with c=screw driver operation as supplied by castle Brass or equal.

f) **Strainers**

Upto to 50mm Malleable iron bodies, stainless steel screen and screwed connections to B.S. 21.

65 and above cast iron or S.C. iron bodies, stainless steel screen and flanged connections.

3.39.4. **Hot water (850°C)**

a) **Piping**

**Piping - Steel**

Stainless steel type 304 L to A.S.T.M specification A312. Wall thickness 2mm minimum longitudinally welded. **NOTE** All welds made in the pipe during manufacture shall be suitably cold worked to relive stresses and normalize crystal structure in order to prevent stress corrosion occurring while the pipe is in service at 85°C. All joints in run and to fittings to be welded, using a suitable inert gas technique.

**Piping - Polypropylene**

Upto to 25mm 1,500 kpa rated. Extruded from polypropylene - ethylene grade and shall be U.V. stabilised, to B.S. 4991 or ISOR 160.

32mm and above 1,500 kpa rated. Extruded from polypropylene -ethylene grade and shall be U.V. stabilised, to B.S. 4991 or ISOR 160.

**Piping - Copper**

Type CU DHP complying with B.S. 2051

b) **Fittings**

**Fittings - Steel**

Stainless steel type 304L welded.

**Fittings - Polypropylene**
Upto to 100mm  Fusion welded of exactly the same material and pressure rating as the polypropylene piping.

125mm and above  Flanged and of exactly the same pressure rating and material as the polypropylene piping.

Fittings - copper

Upto to 50mm  Capillary to B.S. 864 or screwed to B.S. 21. Above 50mm flanged, brazed or bronze welded.

c)  Flanges

Flanges - Steel

Stainless steel type 304L flat face - slip-on, to B.S. 4504.

Flanges - Polypropylene

Full face polypropylene or polypropylene stub flanges with mild steel backing rings drilling to B.S. 4504.

Flanges - copper

Bronze or gunmetal brazed or welded to pipe, B.S. 4504. Brass bolts, nuts and washers to be used.

d)  Gaskets

6mm Rubber insertion.

e)  Valves

Globe (throttling valve only)

Up to 40mm  bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

50mm and above Cast iron body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 4505.

Gate

Up to 40mm bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

50mm and above Cast iron body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 4505.
Valves

Up to 40mm  bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

50mm and above Cast iron body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 4505.

Check Valves

Up to 40mm  bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

50mm and above Cast iron body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 4505.

Ball Valves

Up to 40mm  chrome plated brass, teflon seat rings, screwed to B.S. 21 with fixed operating handle.

Restrictor Valves

Ballstop with screwdriver option.

Finish -  Machined brass unless specified otherwise.

f) Strainers

Up to 50mm  Malleable iron body, stainless steel screen and screwed connections to B.S. 21 65mm and above malleable iron body, stainless steel screen and flanged connections

3.39.5. Hot water (850C)

a) Piping

Piping - Steel

upto 150mm  Steel piping (Black) to B.S. 1387 medium class plain ends for welding.

Above 150mm  Steel piping to B.S. 3601/22 or API Equivalent 4, 5 mm wall thickness plain ends for welding.

Piping - Polypropylene

Upto to 100mm  1,500 kpa rated. Extruded from polypropylene - ethylene grade and shall be U.V. stabilised, to B.S. 4991 or ISOR 160.

b) Fittings

Fittings - Steel
Butt-weld fittings to B.S. 1640.

Fittings - Polypropylene

Upto to 100mm  Fusion welded of exactly the same material and pressure rating as the polypropylene piping.

125mm and above  Butt welded or fusion welded and of exactly the same pressure rating and material as the polypropylene piping.

c) Flanges

Flanges - Steel

B.S. 4504 wrought steel, flat faced, slip on.

Flanges - Polypropylene

Full face polypropylene or polypropylene stub flanges with mild steel backing rings drilling to B.S. 4504.

d) Valves

Up to 50mm  ball valves with bronze body, hard chromed bronze ball, teflon seats, screwed, to B.S. 21. Alternatively forged steel body, stainless steel ball.

65mm and above  globe valves with cast iron body, bronze seating rising spindle, flanged to B.S. 4504.

Check Valves

Non-slam double swing check valves with cast iron body, bronze flaps and neoprene seat, fitted between flanges.

Traps

15mm  Automatic trap with internal strainer, or approved equal.

20mm  Angle strainer fitted before trap or approved equal. All traps to have balance pipe.

Filter, Regulator, Lubricator Sets

8 mm  Complete with pressure gauge and manual operated drains on filter unit.

10, 15, & 25mm  complete with pressure gauge and manual operated drains on filter unit.

Filter and Regulator

As for filter, regulator and lubricator sets but without lubricator.

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e) Moisture separators

Up to 40mm Vertical type screwed inlet and outlet to B.S. 21 complete with drain trap.

32mm and above Horizontal type flanged connections, complete with drain trap.

3.39.6. Chilled Water Pipework

a) Piping

upto 80 mm B.S. 1307 medium class, screwed and socketed.

100mm to 150mm B.S. 1387 medium class, plain ends prepared for welding.

Above 150 mm B.S. 3601/22 or API equivalent with wall thickness 5 mm minimum, plain ends prepared for welding.

b) Fittings

Steel butt-weld fittings to B.S. 1640 or equal, wall thickness not less than pipe thickness or screwed malleable iron fittings as applicable.

c) Flanges B.S. 4504

d) Gaskets Rubber insertion

e) Valves

Cocks - Balancing Valves

Upto to 50mm bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

65mm and above Cast iron body, outside screw and yoke, bolted bonnet, replaceable seating, rising stem incorporation back seal, bronze or stainless steel trim, and flanged to B.S. 4504.

Gate

Upto to 50mm bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

65mm and above Cast iron body, outside screw and yoke, bolted bonnet, replaceable seating, rising stem incorporation back seal, bronze or stainless steel trim, and flanged to B.S. 4504.

Check Valves

Upto to 50mm bronze body, bronze or stainless steel trim, replaceable seating and screwed to B.S. 21.

65mm and above Cast iron body, bronze seating, swing-check,
flanged to B.S. 4504

f) **Strainers**

All strainers to be installed as follows:

Upto 50mm diameter screwed to B.S. 21. 50mm and over flanged to B.S. 4504.

Screwed ends  Bronze body, stainless steel screen.

Flanged ends  Cast Iron body, stainless steel screen.

3.39.7. **Condenser Water Pipework**

a) **Piping**

upto 80 mm  B.S. 1307 medium class, screwed and socketed.- galvanised.

100mm to 150mm  B.S. 1387 medium class. flanged ends - galvanised after manufacture.

Above 150 mm  B.S. 3601/22 or API equivalent with wall thickness 5 mm minimum, flagged ends - galvanised after manufacture.

b) **Fittings**

upto 80 mm  Galvanised malleable iron fittings to B.S. 143 screwed to B.S. 21.

Above 80 mm  Flanged to suit.

c) **Flanges**

upto 80 mm  B.S. 4504 screwed and galvanised.

Above 80 mm  B.S. 4504 slip on. Pipe and Flange galvanised after manufacture.

d) **Gaskets**  Rubber insertion

e) **Valves**

Valves shall be all as specified for chilled water, 17.18.6 e.

f) **Strainers**

Strainers shall be all as specified for chilled water 17.18.6 e.
3.40. GENERAL TECHNICAL SPECIFICATION - COMMISSIONING

3.40.1. General

Before any commissioning work takes place, the sub-contractor shall submit a set of schematic commissioning drawings showing duct runs, and other equipment, air flows, water flows and controls. These drawings to be accompanied by the method proposed for commissioning of the plant, as by the method proposed for commissioning of the plant, as well as the number of people involved, their names and experience. The Engineer’s approval on the above item is essential before any commissioning takes place.

3.40.2. Maintenance Manuals

The Sub-Contractor shall provide, before any commissioning work starts, three copies of the maintenance and operating manuals for the plant supplied. These manuals shall be sewn and bound in book form with hard plastic covers to withstand constant use; and shall be properly indexed to facilitate quick references. Prior to the submission of the three copies mentioned above the Sub-Contractor shall submit one draft copy of the maintenance and operating manuals for approval. The works shall not be considered to be completed for the purposes of taking over until such manuals have been supplied to the Engineer, and subsequent equipment test results have been included in them.

The manuals shall include:-

(a) A list of recommended servicing tools and specialist plant.
(b) A list of recommended spares necessary for a period of 2 years operation.
(c) Exploded drawings or spares lists from which every item of every place of plant can be positively identified of each item of plant.
(d) A list of giving the name and address of the manufacturer of each item of plant.
(e) A copy of all test certificates obtained with the plant.
(f) A list of recommended lubricants.
(g) A preventive maintenance programme for all plant.
(h) Operating instructions for each item of plant.
(i) Performance data, equipment tests and characteristics curves.
3.41. INITIAL TESTING AND PLANT COMMISSIONING

3.41.1. Initial Testing

(a) Pressure Testing - Piping

All pipework system shall be pressure tested by filling with water and raising the pressure to 1.5 times working pressure. They shall then be left for a period of at least one hour during which all joints must remain water-tight. Any fault found during the pressure test shall be remedied and the test reapplied until the same is dealt with completely.

The pipework shall be tested in sections to suit the construction programme and all services in concealed locations shall be tested before they are finally concealed. No insulation shall be applied before tests have been carried out.

The Sub-Contractor shall provide all test equipment and all additional items such as toes, valves, drain fittings, etc. which are necessary to enable the systems to be treated in sections. Each test shall be witnessed by the Engineer or his nominated agent and also a signed certificate of approval shall be obtained.

(b) Draining and Cleaning

On completion of the pressure test on a section of pipework the water used for testing shall be drained away as quickly as possible to remove as much dirt and dross as possible. After completion for a pipework circuit the circuit shall be flushed through to remove all pipe scale, dress and similar material.

(c) Pressure Testing - Ducting

See section on ducting.

(d) Insulation Tests

All electrical wiring and controls integral with the plant supplied shall be subjected to insulation tests. All instrument and other equipment required for the tests shall be provided by the sub-contractor.

(e) Drives

All drives shall be run and tested for direction rotation and correspondence of alignment.

3.41.2. Plant Commissioning

The Sub-Contractor shall check over and test and satisfy himself that all items of plant are correctly assembled and aligned before start-up. This work is to be carried out by skilled commissioning Engineers who are completely familiar with the plant involved.

The Engineer shall vitreous plant commissioning as required by him and the contractor must advise the Engineer prior to any commissioning work taking place.
On completion of the plant commissioning, the Contractor shall provide written confirmation to the Engineer that he has completed all commissioning work and is satisfied that the items of plant are operating satisfactorily.

3.41.3. **Test of Completion**

No completion of the Sub-Contractor’s initial testing and commissioning as specified above, the plant shall be put into normal operation and the final adjustment of the plant shall be made. Thereafter the Tests on completion shall be carried out to ensure that the plant will fulfill the function for which it has been designed. These shall extend for a period of at least four weeks and shall include the following:

(a) Simulated tests for all alarm and safely cut out equipment.

(b) Simulated tests on automatic controls.

(c) Capacity tests to ensure that the plant supplied will handle the quantities specified.

The Engineer reserves the right to witness all tests.

The Sub-Contractor shall utilise the Engineer’s manual Equipment performance and capacity.

The Sub-Contractor shall at his own cost render all assistance and supply all labour, appliances and any other materials, as may be required to carry out these tests. All instruments shall be accurately calibrated before the tests begin.

On completion of the whole of the tests and when the sub-contractor is satisfied that the entire plant is operating satisfactorily and will fulfil the function for which it has been designed, he shall submit to the Engineer triplicate copies of all tests records and charts together with reports on all the tests called for in this specification. The Engineer shall reserve the right to ask for previous tests in order to prove that the operation of the plant is satisfactory and in accordance with the specification and drawings.

The Sub-Contractor shall be responsible for the proper operation and running maintenance of the plant throughout the period of the tests. The Sub-Contractor shall provide full time experienced commissioning Engineers and artisan staff during the entire testing period.

At the commencement of and during the whole of the testing period the Sub-Contractor shall be required to have stored on site all essential spares and tools considered necessary to enable repair work of defective parts to be carried out immediately in the event of a breakdown.

The operation and maintenance manuals shall be completed and handed over to the Engineer before the start of any commissioning work and in any case, prior to the issuing by the Engineer of the taking-over certificates. The period of maintenance shall be deemed to have started upon the date of issuing of the taking-over certificate.
3.42. OPERATOR TRAINING PERIOD

The Operator Training Period on the whole of the works or on any part thereof shall commence at the date to be fixed after the issue of the taking over certificate and mutually agreed with the Engineer. This period shall continue for a period sufficient to ensure that the operations are fully conversant with the functions they are to perform, but shall not exceed a period of 5 days.

The Contractor shall provide full-time instructions during the entire operator training period who shall be fully experienced in the class of work and shall be capable of training the operating and maintenance staff in the duties they are to perform.

3.43. PERIOD OF MAINTENANCE (Defects Liability)

The expression period of maintenance shall mean a period of 12 months from the date of taking over in accordance with Clause 3.3 hereof.
PARTICULAR SPECIFICATION

FOR

MECHANICAL VENTILATION, AIR CONDITIONING AND REFRIGERATION SERVICES
4. PART D: PARTICULAR SPECIFICATION FOR MECHANICAL VENTILATION, AIR CONDITIONING AND REFRIGERATION SERVICES

4.1. Particular Conditions

4.2. Location of Site

The site of the proposed project shall be situated at Kenyatta Hospital, Off Ngong Road, and Nairobi.

4.3. Description of the Project

The project objective is to establish the East Africa Kidney Institute Project, which shall be a centre of excellence for kidney related diseases in the East Africa Region. The project shall entail development of a complex to accommodate wards, theatres, dialysis units, administration offices, data centre and plant rooms. The complex will entail a Basement, Ground, First, Second, Third and Fourth Floors.

4.4. Commencement of Works

The Sub-Contractor in submitting his tender shall be deemed to have included for commencing any necessary work on site at such time as will comply with the Main Contractor's programme.

4.5. Climatic Conditions

The following climatic conditions apply at site of the works and all plant, equipment, apparatus, materials and installations shall be suitable for these conditions.

Where not otherwise stated, all rating of plant, equipment and apparatus shall be interpreted at site ratings and NOT sea level or other ratings.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum temperature</td>
<td>31.5°C</td>
</tr>
<tr>
<td>Minimum temperature</td>
<td>5.2°C</td>
</tr>
<tr>
<td>Average Diurnal Range</td>
<td>11.7°C</td>
</tr>
<tr>
<td>Relative humidity range</td>
<td>48-93%</td>
</tr>
<tr>
<td>Altitude</td>
<td>1775m above sea level</td>
</tr>
<tr>
<td>Latitude</td>
<td>01 19’S</td>
</tr>
<tr>
<td>Longitude</td>
<td>36° 49'E</td>
</tr>
<tr>
<td>Mean Rainfall</td>
<td>911mm per year.</td>
</tr>
<tr>
<td>Maximum Rainfall</td>
<td>1475mm</td>
</tr>
</tbody>
</table>

The Sub-Contractor shall be deemed to have taken account of the above details in his prices and his planning of the execution of the works.
4.6. Scope of the Sub-Contract Works

The Sub-Contract shall comprise the supply, delivery, erection, testing, commissioning and setting to work of mechanical ventilation and air conditioning systems detailed in this Specification and the accompanying Contract Drawings.

The Sub-Contract Works shall include for all appurtenances and appliances not particularly called for in this Specification or on the Contract Drawings but which are necessary for the completion and satisfactory functioning of the Sub-Contract Works.

No claims for extra payment shall be accepted from the Sub-Contractor due to his failure to adhere to the above requirements. It is deemed that if, in the opinion of the sub-contractor at the time of tendering, there existed a difference between the Specification and the Contract Drawings that the Sub-Contractor clarified this difference with the Engineer before tendering.

The works to be installed under the Sub-Contract shall comprise air conditioning but not restricted to mechanical ventilation systems, air conditioning and refrigeration systems as described and shown on the drawings.

4.7. Design Conditions

The air conditioning systems are designed to maintain particular specified internal conditions with an external ambient temperature of 27.3°C db and 16.5 wb.

4.8. Air Conditioning System

Natural ventilation shall be encouraged as much as possible with mechanical ventilation and air conditioning being adapted to suit specific operational requirements.

The proposed air conditioning shall vary from complex air cooled ducted systems to split units depending in room occupancy, sound levels, energy saving considerations and environmental impact shall be carefully considered at design stage. Care shall be taken to ensure fresh air replenishments and filtration to acceptable limits. In the conference and courtrooms low level grilles shall be incorporated to handle foul smell that might emanate from foot wear and solid particles.

Variable refrigerant volume systems shall be proposed in committee rooms and conference rooms with less than 100 pax.

The modern direct expansion variable Refrigerant Volume (VRV) units with automated controls and sensors shall be incorporated in the works. The system offers advantages in more refined and quick acting controls, low power consumption due to efficient equipment and heat transfer systems and lower plant spatial requirements among others.

The air handling units and indoor fan coil units shall be chosen and designed to suit duty requirements for the areas served. Care shall be exercised to ensure uniform distribution of air to avoid direct draughts to the occupants and also avoiding hot and cold spots. Air freshness shall also be critically addressed in the designs. The rooms and especially the conference rooms etc. shall be maintained at positive pressure to preclude dust ingress.

The system design shall allow for differential settings for individual enclosed areas served.
Mini-split systems proposed for adoption from the variable refrigerant flow system ranges are currently the “state of the art” air conditioning solutions for light commercial application and are most suitable for meeting and conference rooms. The latest technology touches on areas such as:

- Modified DC compressors which use ozone friendly refrigerants.
- Distance between indoor units and outdoor ranging from 30m to 150m equivalent depending on product and relative elevation between outdoor unit and indoor units which allows flexibility of installing the “noisy” outdoor units away from building occupants.
- Electronic controls allow significant energy savings by modulating control valves in each indoor unit hence vary refrigerant flow depending on thermal energy element. It is possible to transmit these signals to outdoor unit(s) in order to optimize on energy consumption.
- The system offers individual room control depending on occupancy and hence offers a more economical and efficient system.
- The system can be supplied with central control system for units between 8 No. to 500 No. depending on product, and incorporating other attributes such as:
  - Temperature adjustments controls
  - Scheduled maintenance notification
  - Timers with memory retention
- The system can also be supplied with network control system for autonomous monitoring of the air conditioning system and integrated to communicate with Building Management Systems and to monitor operational status.

Limitations

The indoor units for variable refrigerant flow system are limited in individual cooling capacity to 28kW each (maximum). The other limitation is that whenever one or more compressors is defective the whole installation must be stopped for repair/maintenance hence no redundancies or partial performance. This also applies to electronic control units and therefore, mission critical rooms must have split stand by provisions at all times.

The other limitation is low fresh air turn over hence unsuitable for highly occupied areas like the waiting rooms and conference rooms. Separate and independent rooms shall be designed to suit space especially where demountable partitions are proposed to ensure systems operate at optimum demand levels hence save on energy and ensure long plant live.

Air discharge units (grilles) and ducts shall be designed to ensure silent operation with attenuation incorporated in the designs. This is to ensure a serene atmosphere required. Grille patterns and finishes shall be selected in close liaison with the Architect to ensure harmony with the interior décor.

Maintenance and environmental considerations shall be critically addressed to ensure that equipment incorporated in the works are maintainable. Only environmentally friendly
units, with local representation and spare parts distribution and from reknown models with proven past performance shall be considered. Systems with ozone depleting C.F.C based refrigerants shall not be considered.

Extract systems for landlocked cloak and changing rooms will be proposed to enhance air flows and remove odours. Areas with good cross ventilation shall be kept under natural ventilation.

High precision Air conditioning units shall be proposed in sensitive ICT and equipment rooms with duty and standby units to ensure reliability and long equipment live. The cooling loads shall be worked out in liaison with specialist equipment suppliers to ensure right sizing and appropriate controls. The designs shall allow for reasonable future expansion. All the air conditioning shall be BMS compliant for ease of monitoring, scheduled maintenance and operation.

All advantages shall be exploited for maximum benefit while limitations shall be carefully analyzed and mitigated in design.

4.9. Extract Fans

These shall be similar or equal to WOODS fans manufactured by Woods of Colchester of the United Kingdom. The fan to be standard length type with a casing that covers the overall length of the impeller and the motor.

4.10. Hoods

The hood shall be fabricated from 1.8mm thick Aluminium sheet steel, covering the entire Hood. ‘Vokes’ filters will be included each size 500 x 686 x 565mm. Hoodlights as PL bulkhead fittings, 18 Watts, or equal and approved.

The hood should be installed at a minimum height of 1900mm from the finished floor level. A 75 x 40mm grease drain channel will be incorporated in the hood inclusive of 8 No. drain plugs. Hoods designs shall be issued on approval from the Client.

4.11. Cold Room Specification

The installation shall be of insulation clad stonework room.

Construction

The Sub-Contractor shall be responsible for supply and installation of the cold room doors, refrigeration equipment, copper tubing, refrigeration controls and control panel and all the other appurtenances and appliances necessary for the current functioning of plant.

The Sub-Contractor shall also be responsible for liaison with all other trades to ensure that all provisions for power and builder’s works are fitted to suit the works.

All electric motors shall be totally enclosed, weather proofed, tropicalized, fan colled and of high efficiency.

Insulation
To be polystyrene (styropor) on timber frame with a 13mm tar/bitumen water seal and chicken mesh reinforced plaster with water proof paint supplied and installed by the builder.

**Finish**

The interior of walls to be plastered and moisture resistant painted. The roof interior to be plastered insulated concrete slab laid by builder. The floor to be styropor insulated water sealed concrete slab with screed all laid by builder.

4.12. **Doors**

Standard door finish to the exterior in seasoned hardwood. Lockable door is flush fitting giving clear opening of 800mm wide plus 1875mm high with heavy duty chrome plated, self-closing left or right hand hinges. Handles shall be heavy duty level type with lock and inner safety release doors sited with snubber rubber to ensure positive closing and to hold the door close against high pressure inside the room. The door frame shall be supplied with 150mm Architrave all-round the door opening. The Sub-Contractor to ensure that the correct door opening is left by the builder during construction.

4.13. **Connections**

The Sub-Contractor shall supply and install all connecting refrigeration pipework between the condenser unit and the cooling coils and all electrical wiring from isolators adjacent to the condensing unit and control panel shall be by the refrigeration system Sub-Contractor.

4.14. **Condensing Units**

All condensing units shall comprise of open-type belt driven compressors and shall be air cooled. They shall also incorporate a finned tube condenser assembly, a four bladed fan and an external electric cable connection box. The whole unit shall be mounted on a solid steel base frame complete with anti-vibration mountings and be suitably charged with ZONE friendly refrigerant. They shall also be suitable for operation at an altitude of 1608 metres above seal level.

4.15. **Cooling Units**

All cooling units shall comprise of a copper tube/aluminium fins cooler block, four bladed propeller type air circulation fan, refrigerant controls and fan guards. They shall be mounted on a light all steel rigid mounting frame enclosed in an aluminium casing, shall be suitable for ceiling, fixing and be capable of operation at an altitude of 1608 metres above sea level, condensation from the cooling unit drip trays shall be suitably trapped and piped away to the nearest soil pipe.
4.16. **Interior Lights**

Single bulkhead light fittings suitable for low temperature operation shall be installed in the cold rooms.

4.17. **Control Panels**

All the cold rooms shall be complete with a suitable wall mounted control panel incorporating adjustable thermostatic controls, temperature recorders, manual ‘stop/start’ apparatus with green light running indication, red light ‘door open’ indication and complete with micro-switch, terminal block and fuses.

4.18. **Air Duct Accessories**

**General**

- Each accessory shall guarantee selected technical data such as discharge or crossing speed, pressure drops, deadening properties or noise, fire proofing, etc.), certified by the Manufacturer;

- Before ordering, technical data typical of each component mentioned in this specification shall be submitted to the Client.

**Silencer**

Silencers shall be:

- On rectangular section duct:
  - Frame: of galvanized steel sheet, minimum thickness 15/10 mm (*);
  - Silencing baffle plates: self-extinguishing Class 1 certified, moisture-proof, protected against chipping, suitable for a maximum air speed of 20 m/s (*);
  - Connections: flanged type;

- On circular section ducts:
  - Frame: cylindrical casing made of galvanized steel plate, minimum thickness 15/10 mm (*);
  - Internal lining: galvanized steel drilled plate (*);
  - Internal silencing ogive;
  - Silencing material: self-extinguishing Class 1 certified, moisture-proof, protected against chipping, suitable for air maximum speed of 20 m/s (*);
  - Connections: flanged.

(*) all the materials must be compatible for hospital applications;

Technical data to identify silencer technical characteristics shall be as follows:

- Air flow (m3/h);
- Attenuation (dB(A) and octave bands);
- Dimensions (mm BxHxL);
- N° of panels;
- Distance between panels;
- Panel dimensions (mm);
- Pressure drop (Pa).

**Control damper**

Control Damper for Circular Ducts
A control damper, made up of a rugged steel plate framework, shall be provided for fitting on ducts; it will control air flow and pressure inside the duct by a diaphragm allowing a perfect calibration and a negligible increase in turbulence and sound level.

It will be equipped with connecting devices to measure duct flow rate and pressure. The diaphragm position adjustment shall be made by a manually operated lever, equipped with a locking device and graduated scale.

Control Damper for Rectangular Ducts
This control damper shall be made of a rugged steel plate framework to be fitted on ducts; it will control air flow and pressure inside the duct through opposed galvanised steel fins, pivoted on bronze bushings.

Fin position control shall be made through a lever placed sideways, manually or power operated.

The maximum adjustable pressure shall be up to 650 Pa.

**Linear diffuser**
Linear diffuser for air supply and extraction shall have the following characteristics:
- anodised aluminium construction;
- one to four rows of individually adjustable fins; small blade damper; connection chamber with thermal insulating and deadening internal lining, class 1 certified, provided with drilled plate for air flow equalization;
- Suitable for false-ceiling installation;
- High induction ratio with ambient air, silent operation and reduced pressure drops.

**Inlet grille**
Inlet grilles to be wall or ceiling mounted shall have the following characteristics:
- Extruded aluminium frame;
- Aluminium section chassis;
- Extruded aluminium fixed fins;
- Wall-mounting by internal pawls;
- control damper, manually operated by a screwdriver from the outside; galvanised steel chassis and extruded aluminium fins;
- Control by opposite motion of fins placed side by side on the short side;
- Galvanised steel counter-frame.

**Transfer air grille**
Transfer air grilles shall be provided for door and wall installations to transfer remaining air from one room to another.

The maximum permissible velocity of flow shall be equal or less than 1, 0 m/s.

The transfer air grille shall comprise two equal front sections consisting of a frame with horizontally fixed non-vision blades, made of angular profiled extruded aluminium and additional opposite blind frame.

The transfer air grille shall be designed with regard to a smooth and heavy construction.

**Disc valve**
Disc valves shall be provided for exhaust and air-intake by installation within suspended ceilings of toilets, showers, etc.
The disc valves shall be designed in consideration of the required pressure drop and low noise as specified.

All disc valves shall be adjustable by twisting the valve disc. The dsc valve shall comprise a valve housing and a valve disc made of white finished, stove-enamelled sheet steel, including built-in rear mounting frame with an adjustable spindle and lock-nut made of galvanized sheet steel and additional gasket ring.

Supply and return grille
Supply and return grilles shall be provided for air distribution systems installed visibly in plant rooms, etc. as specified. All supply and return grilles shall be designed with regard to high induction and low noise level.

All supply and return air grilles shall comprise a front section consisting of a frame with individual adjustable aerofoil blades and made of anodised aluminium with galvanised steel plate chassis with stove enamelled finish, including rear built-in flow regulating device, made of common adjustable and contra-rotating coupled blades or adjustable baffle plate. Grille fastening to the chassis by chromium-plated screw.

Supply air grilles shall be equipped with vertical front blades, additional rear built-in horizontal blades, individual adjustable and contra-rotating flow regulating device. Return air grilles shall be equipped with horizontal front blades and baffle flow regulating device.

Air extraction PVC openings
Air extraction opening intended for corrosive atmosphere shall have suitable characteristics and be entirely PVC manufactured.

Each air extraction opening shall have a single set of inserted fins and include a control damper with opposed fins, also made in PVC.

4.19. Grilles

(a) Extract Grilles shall be similar to the extract registers described below with the exception that they shall have only one set of blades parallel to the long dimension.

(b) Extract Registers – The registers shall be similar or equal to type Deflector as manufactured by Myson Group Market and of size and diffusion patterns as indicated on the Contract Drawings.

The registers shall be manufactured from high grade extruded aluminium sections with lacquered finish, bevelled flanges and removable core. Fixing shall be by self tapping screws through the duct into the neck of the register.

4.20. Control Panels

The Sub-Contractor under this sub-contract shall supply control panel for the kitchen extract system and install the same in the building.

The control panels shall be fabricated from 1.2mm thick sheet and finished in grey stoved enamel or other approved material. The panels shall be moisture, insect and rodent proof.
They shall be provided complete with spare fuses and wiring diagram enclosed in plastic laminate.

The positions of the control panel shall be as shown on the sub-contract drawings. The sub-contractor shall include for the final connection of the wiring to the control panel and the fans. The control panel shall be provided as detailed and comprising the following:-

1. Main Isolator  
2. Auto/Manual Switch  
3. Fan start/stop push buttons  
4. Fan run/fail green/red light indicators  
5. In the event of a fire both fans shall be initiated automatically by the fire alarm system and shall be connected to the maintained electrical supply.

4.21. Electrical Works

4.21.1. General

It shall be the responsibility of others to provide all electrical wiring in between all items of equipment. The Sub-Contractor however, must provide the Main Contractor with complete electrical drawings and diagrams for the operation of all controls and equipment so as to permit the correct electrical connection of equipment.

The Sub-Contractor must provide adequate supervision and liaison with those employed to carry out the electrical wiring, and shall ensure that all wiring and connections are to his satisfaction to ensure the correct functioning and operation of equipment.

The Sub-Contractor shall hand to the Main Contractor for fixing by others all wall mounted humidity and temperature detectors.

The Sub-Contractor shall provide all electrical control panels as described in this Specification and shall be responsible for all their fixing and satisfactory operation. The control panels shall be fabricated from 1.2mm thick sheet steel and finished in grey stoved enamel. The panels shall be either floor or wall mounted of compartmentalised design with removable, hinged, front access panels. Switchgear shall be Asea, Brown Klock-Moeller or equal and approved.

All items of motorised plant shall have local stop/start, green running and red failure lamps on the face of the panels for each motor.

All panels shall have an integral isolator for complete isolation of each individual panel.
PARTICULAR SPECIFICATION FOR
HIGH TECHNOLOGY DEVICES DESCRIPTION
5. PART E: PARTICULAR SPECIFICATION FOR HIGH TECHNOLOGY DEVICES DESCRIPTION

5.1. AIR HANDLING UNITS

5.1.1. AHU side by side type (AHU05-06-07-08-15) – flow rate 3.000 cm/h

Outdoor AHU side by side type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification. The side by side AHU will be placed under a deck and the maximum height of both sections (return and supply) must not exceed 1 meter.

5.1.2. AHU overlying type (AHU11) – flow rate 4.000 cm/h

Outdoor AHU overlying type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification.
5.1.3. **AHU side by side type (AHU14) – flow rate 8.000 cm/h**

Outdoor AHU side by side type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification. The side by side AHU will be placed under a deck and the maximum height of both sections (return and supply) must not exceed 1 meter.

5.1.4. **AHU side by side type (AHU12) – flow rate 9.000 cm/h**

Outdoor AHU side by side type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be

5.1.5. **AHU side by side type (AHU10) – flow rate 10.000 cm/h**

Outdoor AHU side by side type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings.
The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipments are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification. The side by side AHU will be placed under a deck and the maximum height of both sections (return and supply) must not exceed 1 meter.

5.1.6. **AHU overlying type (AHU01-02-03-04-09) – flow rate 14.500 cm/h**

Outdoor AHU overlying type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipments are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification.

5.1.7. **AHU overlying type (AHU13) – flow rate 16.000 cm/h**

Outdoor AHU overlying type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel,
thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board.

Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings.

All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification.

5.1.8. **AHU overlying type (AHU16) – flow rate 8.000 cm/h (sterilization)**

Outdoor AHU overlying type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanised steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment’s are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification.

5.2. **STEAM HUMIDIFIER**

5.2.1. **Steam Humidifier - production: 13 kg/h**

The steam humidifier is used for AHU with a flow rate from 3.000 up to 4.000 cm/h; it is mainly equipped with: feed tank; conductivity meter; thermal protector relay to protect against excess heater temperature; solid state relay to modulate steam flow-rate; level sensor to guarantee the complete heater immersion; main control board; cylinder AISI304 steel lined with heat insulation. Drain pump. The steam humidifier produces 13 kg/h of steam with 10 kW of power consumption. The steam humidifier produces non-pressurized steam using heating elements immersed in the water contained in a cylinder. To achieve uniform distribution of the heat flow, the heating elements, which are electrically insulated from the water, are covered in an aluminium casting. The heaters must be completely immersed in the water at all times, to avoid overheating. Immersed heater humidifiers thus require level sensors to ensure complete heater immersion, as well as components (solid state relays) to modulate the quantity of heat delivered to the water so as to precisely control steam flow-rate.

5.2.2. **Steam Humidifier - production: 40 kg/h**

The steam humidifier The steam humidifier is used for AHU with a flow rate from 8.000 up to 10.000 cm/h; it is mainly equipped with: feed tank; conductivity meter; thermal...
protector relay to protect against excess heater temperature; solid state relay to modulate steam flow-rate; level sensor to guarantee the complete heater immersion; main control board; cylinder AISI304 steel lined with heat insulation. Drain pump. The steam humidifier produces 40 kg/h of steam with 30 kW of power consumption. The steam humidifier produces non-pressurised steam using heating elements immersed in the water contained in a cylinder. To achieve uniform distribution of the heat flow, the heating elements, which are electrically insulated from the water, are covered in an aluminium casting.

The heaters must be completely immersed in the water at all times, to avoid overheating. Immersed heater humidifiers thus require level sensors to ensure complete heater immersion, as well as components (solid state relays) to modulate the quantity of heat delivered to the water so as to precisely control steam flow-rate.

5.2.3. Steam Humidifier - production: 53 kg/h

The steam humidifier is used for AHU with a flow rate of 14.500 cm/h; it is mainly equipped with: feed tank; conductivity meter; thermal protector relay to protect against excess heater temperature; solid state relay to modulate steam flow-rate; level sensor to guarantee the complete heater immersion; main control board; cylinder AISI304 steel lined with heat insulation. Drain pump. The steam humidifier produces 53 kg/h of steam with 40 kW of power consumption. The steam humidifier produces non-pressurised steam using heating elements immersed in the water contained in a cylinder. To achieve uniform distribution of the heat flow, the heating elements, which are electrically insulated from the water, are covered in an aluminium casting. The heaters must be completely immersed in the water at all times, to avoid overheating. Immersed heater humidifiers thus require level sensors to ensure complete heater immersion, as well as components (solid state relays) to modulate the quantity of heat delivered to the water so as to precisely control steam flow-rate.

5.2.4. Steam Humidifier - production: 60 kg/h

The steam humidifier is used for AHU with a flow rate of 16.000 cm/h; it is mainly equipped with: feed tank; conductivity meter; thermal protector relay to protect against excess heater temperature; solid state relay to modulate steam flow-rate; level sensor to guarantee the complete heater immersion; main control board; cylinder AISI304 steel lined with heat insulation. Drain pump. The steam humidifier produces 60 kg/h of steam with 45.7 kW of power consumption. The steam humidifier produces non-pressurised steam using heating elements immersed in the water contained in a cylinder. To achieve uniform distribution of the heat flow, the heating elements, which are electrically insulated from the water, are covered in an aluminium casting. The heaters must be completely immersed in the water at all times, to avoid overheating. Immersed heater humidifiers thus require level sensors to ensure complete heater immersion, as well as components (solid state relays) to modulate the quantity of heat delivered to the water so as to precisely control steam flow-rate.
5.3. POST HEATING COILS

5.3.1. Post Heating Coils for Ducts – flow rate 500-1000 m³/h

Supply and Installation of duct hot water post heating coil, including valve regulation, ambient temperature probe, pipes connection to mains, fittings, valves, drain, vent. The post heating coil will be also equipped with a regulation system with a 3 way valve, modulating, regulator, probes, connections to regulators and probes and all expenses and charges, electrical connections to control panel, to perform the works.

5.3.2. Post Heating Coils for Ducts – flow rate 1000-2000 m³/h

Supply and Installation of duct hot water post heating coil, including valve regulation, ambient temperature probe, pipes connection to mains, fittings, valves, drain, vent. The post heating coil will be also equipped with a regulation system with a 3 way valve, modulating, regulator, probes, connections to regulators and probes and all expenses and charges, electrical connections to control panel, to perform the works.

5.3.3. Post Heating Coils for Ducts – flow rate 2000-4000 m³/h

Supply and Installation of duct hot water post heating coil, including valve regulation, ambient temperature probe, pipes connection to mains, fittings, valves, drain, vent. The post heating coil will be also equipped with a regulation system with a 3 way valve, modulating, regulator, probes, connections to regulators and probes and all expenses and charges, electrical connections to control panel, to perform the works.

5.4. HEPA H14 FILTER

5.4.1. HEPA H14 Filters - 762x762x68 mm

Supply and installation of HEPA H14 filters, these will be SAGI COFIM type Delta AB, Delta AA or similar, these absolute filters are mini-pleated, not very deep, for unidirectional flow system applications. All the filters have an extruded anodized aluminium frame, 69 mm deep, with white epoxy painted micro-drawn steel protection grids. The filtration splitter is in micro-fiber glass, water-proof and fire-proof; the small pleats are fitted with thermoplastic continuous separators, whereas the sealant is made of polyurethane. The filters are also fitted with a one piece gasket. Low pressure drop levels limit fan energy consumption levels. All the filters are individually tested and labelled to indicate performance levels; including accessories as stated in drawings.

5.4.2. Terminal Hoods for HEPA H14 Filters - 787x787x445 mm

Supply and installation of Terminal hoods for HEPA H14 filters, these will be SAGI COFIM type DIF.P or similar; DIF.P WT High induction diffuser terminals are made of an anodized aluminium frame which holds the DELTA series, including accessories and all expenses and charges to perform the works as stated in drawings.
5.5. OPERATING THEATER

5.5.1. Ceiling Filter System for Operating Rooms

Laminar flow ceiling will be installed in all operating theatre, the laminae flow ceiling and all accessories will be ADMECO ULD 32/32 V6 or equivalent

Laminar Flow Ceiling System ULD 32/32 V6 differential
Use in operating rooms to provide low-turbulence displacement airflow, to be installed in the ceiling void, including:
1 x Laminar airflow ceiling system module ULD 32/32
2 x Integrated air recycling ceiling units for OR rooms each with a total of 6 integrated fan units
2 x Intake suction channels with range of possible positions,

Total recirculated airflow: 5735 m³/h
External airflow: 3000 m³/h
Laminar total airflow: 8735 m³/h

5.5.2. Laminar Airflow Ceiling

To create a vertical, low-turbulence, low-resistance clean airflow comprising:
Load-bearing torsion-stiffened outflow frame designed as a stable attachment point for the air guiding skirts. Clean-room-side structure as filter-frame section from extruded anodised aluminium profile to hold the high efficiency submicron particulate air filter set horizontally immediately prior to air outlet. Filtering system shall provide not less then HEPA 14 performances Large surface laminar fabric with minimal ridging, stable flow-optimised extruded anodised aluminium profile frame, fastened with a screw less fitting to the filter frame section. Narrow ridges to minimise induction (max. ridge width 2.5mm). Perfect hygienic OR lights lead through the disperser with minimised blind surfaces.

Double-seal system filter assembly to ensure secure no-leak filter seals, a noleak filter frame and a secure no-leak overall frame structure. Pre-filtered air side structure as air-tight pressure chamber above the submicron particulate air filter (pre-filtered air side), clear anodised aluminium, material AlMg1, 1mm, with connecting fittings for airflow silencer and mixing section with connecting sleeves for external air. The airtight centred OR light lead through is easily accessible on the cleanroom side for later OR light pendant adjustment. To counter the possibility of fluff entering the OR field, the system on the clean air side is constructed as a continuous smooth surface without screws or joints.

Laminar airflow ceiling with surrounding ceiling bearing angled brackets of powder-coated RAL 9010 aluminium to connect to the existing ceiling.

Technical data
Measurements: 3181 x 3181 x 650 mm
Pressure loss: ca. 60 Pa
Air outlet speed: at 8735 m³/h = 0.25 m/s
No. of filters: 22 x H14 610x610x78 mm
2 x H14 762x610x78 mm
Filter seal: Dual seal system
Connector fittings: 2 pieces 750x200 or as project requirements
OR lights leadthrough: 1
Air stream distributor: Acotex, differential

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5.5.3. **Laminar Air Recycling Module V6**

For the above laminar airflow ceiling, comprising:
Laminar air recycling suction unit with fluff guard of robust woven polyester fabric, easy to disassemble, screw less fitting, with integrated F7 pre-filter, and soundproofed anodised aluminium housing. Connected via anodised aluminium lateral input channels set at a distance to the closed fan units. Fan unit easily accessible for inspection purposes, interior anodised aluminium, exterior galvanised steel, with integrated gravimetric, self-closing return flap over the pressure-side buffer connected to the laminar airflow ceiling.

An EC radial blower per fan unit with direct current motor, volume flow with detector to automatically regulate the dispersal speeds set for the project and ensure they remain constant, via module internal regulation. This ensures the total airflow volume remains constant even if one of the recycling fans should fail or external air intake is restricted. As a result, OR procedures can continue without the risk of interruption.

The recycling fans are completely pre-wired at a central interconnecting station where the incoming power supply link and the control /signalling line is then connected.

The following connections are available for customer-side monitoring and control of the recycling laminar airflow units:
- Analogue 0-10V internal detector output signal for connection to the DDC
- Collective fault message for all recycling airflow fans via potential-free contact
- Module nominal voltage: 3x 230V/50Hz
- Centred overall acoustic pressure level 48 dB(A) under the laminar flow outlet at a height of 1.7m with basic level <= 38 dB(A)

Recycling laminar airflow units with surrounding ceiling bearing angled brackets of powder-coated RAL 9010 aluminium to connect to the existing ceiling.

5.5.4. **Technical data for the laminar air recycling modules**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow module measurements:</td>
<td>3181 x 666 x 450 mm (minimum 450 mm)</td>
</tr>
<tr>
<td>Air intake measurements:</td>
<td>3568 x 400 x 450 mm (minimum 450 mm)</td>
</tr>
<tr>
<td>Pre-filters:</td>
<td>6 x F7 (EN 779)</td>
</tr>
<tr>
<td>No. of fan units:</td>
<td>6</td>
</tr>
<tr>
<td>No. of self-closing flaps:</td>
<td>3</td>
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<tr>
<td>Type of self-closing flap:</td>
<td>Gravimetric</td>
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<tr>
<td><strong>Technical data for the individual fan units:</strong></td>
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<tr>
<td>Airflow volume:</td>
<td>ca. 955 m3/h</td>
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<td>Operating stages:</td>
<td>3 (OR operational and reduced mode and off)</td>
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<tr>
<td>Control via:</td>
<td>2 x external relays</td>
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<tr>
<td>Fan monitoring:</td>
<td>Potential-free fault message</td>
</tr>
<tr>
<td>Nominal current consumption:</td>
<td>max. 2.4A</td>
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<tr>
<td>Protective system:</td>
<td>min. IP 20</td>
</tr>
<tr>
<td>Power consumption:</td>
<td>at 1000 m3/h (80 Pa): ca. 120W</td>
</tr>
</tbody>
</table>
5.5.5. **Air guiding skirt 32/32**

Designed to help prevent the intrusion of contaminated non-filtered air from the area outside the operating field. Surrounding air-guiding skirts, suspended from ceiling-level, fastened to the ULD or the lower edge of a circular indirect lighting module, with skirts comprising four-layer laminated safety glass (VSG) 6.0mm, fitted at the top, the bottom and sides into clear anodised aluminium profiles.

**Technical data**
- **Measurements:** 3181 x 3181 mm
- **Height:** 500 mm
- **Prepared for LSG thickness:** 6.0 mm

5.5.6. **Indirect OR field lighting 32/32**

The indirect OR field circular lighting module fitted with dimmer, fitting directly into the outflow frame of the laminar airflow ceiling, providing non-dazzling lighting for the sterile work zone. Ideal for incorporating surface mounted luminaires. Electrostatic powder-coated front, standard colour: white RAL 9010.

The light band profile forms a close seal with the plastic luminaire covers and, together with the airflow skirts, creates a unified downward level. The lighting module is positioned around the laminar flow outlet between four assembly columns. The module incorporates high-gloss mirror reflectors able to generate approx. 1500 lx illuminance (working height) in the OR field.

The surface mounted luminaires are fully wired and connected and can be dimmed via an appropriate switch on the 230 V side. The power line connection is led out of the light band profile.

**Technical data**
- **Measurements:** 4 items 3181x151x151 mm
- **Equipped with:** 8 x surface mounted luminaires
- **Electronic ballast:** 2x80 W T16 dimmable
- **Protective system:** IP 65 to intermediate ceiling
- **Protective Class:** Nominal voltage: 230 V, 50 Hz Standard
colour: white RAL 9010
- **Illuminance in OR field:** ca. 1500 lx

5.5.7. **Extraction Grilles for Operating Theatre - Top Extraction Grill 350x350 mm**

Supply and installation of stainless steel Extraction grilles for operating theatre SAGI COFIM type DEC-S or equivalent. The grilles mod. "DEC", which are specific for controlled contamination environments. Structure: AISI 304 Stainless steel, Panel: AISI 304 stainless steel; including AISI 304 stainless steel plenum, filter G4 efficiency, flow adjustment damper, accessories and all expenses and charges to perform the works as stated in drawings.

5.5.8. **Extraction Grilles for Operating Theatre - Bottom Extraction Grill 350x350 mm**
Supply and installation of stainless steel Extraction grilles for operating theatre SAGI COFIM type DEC-S or equivalent. The grilles mod. "DEC", which are specific for controlled contamination environments. Structure: AISI 304 Stainless steel, Panel: AISI 304 stainless steel; including AISI 304 stainless steel plenum, filter G4 efficiency, flow adjustment damper, accessories and all expenses and charges to perform the works as stated in drawings.

5.6. DIRECT EXPANSION

5.6.1. Direct Expansion System for UPS

Direct expansion system for UPS mainly formed by 1 outdoor unit and 2 indoor units with R410A gas for heating and cooling, with inverter control system. The system is a reversible heat pump providing cooling in summer and heating in winter with an automatic change over according to external conditions and it is mainly composed by: n°1 outdoor unit for heating and cooling with heat recovery and R410A gas and air condensate, cooling power 22.4 kWc, heating power 25 kWt each unit; n° 2 internal units wall mounted cooling power 11.2 kWc, heating power 12.5 kWt; n°1 central controller for the management of the direct expansion system equipped with a LCD coor touch screen display. Pre-insulated copper pipeline from outdoor unit to direct expansion coil; joints. High-density polyethylene piping for condensate drainage network of all indoor and outdoor units.

5.6.2. Direct Expansion System for CED Room

Direct expansion system for CED room mainly formed by 1 outdoor unit and 2 indoor units with R410A gas for heating and cooling, with inverter control system. The system is a reversible heat pump providing cooling in summer and heating in winter with an automatic change over according to external conditions and it is mainly composed by: n°1 outdoor unit for heating and cooling with heat recovery and R410A gas and air condensate, cooling power 33.5 kWc each unit, heating power 37.5 kWt each unit; n° 3 internal units cooling power 11.2 kWc, heating power 12.5 kWt; n°1 central controller for the management of the direct expansion system equipped with a LCD coor touch screen display. Pre-insulated copper pipeline from outdoor unit to direct expansion coil; joints. High-density polyethylene piping for condensate drainage network of all indoor and outdoor units.

5.7. HEATING/COOLING PLANT

5.7.1. Chiller/Heat Pump Multi-tube 6 pipes – 982 kWc / 931 kWt

The chiller/heat pump multi-tube 6 pipes mainly include is used for the simultaneous production of chilled and hot water in two independent hydronic circuits and one domestic water circuit. The unit is able to simultaneously satisfy the demand for hot and cold water through a system that does not require seasonal switching. Each circuit works with a variable speed drive semi-hermetic screw compressor using R134a, two shell and tubes heat exchangers and a source side coil heat exchanger shared by both circuits. The cooling power is 982 kWc, the heating low temperature power is 931 kW. The system is equipped with a screw inverter technology. To produce domestic hot water an additional system is integrated inside the chiller/heat pump; the second stage overheat system allows to produce hot water up to 78°C with a total heating high temperature power of 279 kWt.
PART F

BILLS OF QUANTITIES
6. **PART F: BILLS OF QUANTITIES**

6.1. **GENERAL NOTES TO TENDERERS**

1. The Bills of Quantities form part of the contract documents and are to be read in conjunction with the contract drawings and general specifications of materials and works.

2. The prices quoted shall be deemed to include for all obligations under the sub-contract including but not limited to supply of materials, labour, delivery to site, storage on site, installation, testing, commissioning **(excluding 16% VAT)**.

3. All prices omitted from any item, section or part of the Bills of Quantities shall be deemed to have been included to another item, section or part thereof.

4. The brief description of the items given in the Bills of Quantities are for the purpose of establishing a standard to which the sub-contractor shall adhere. Otherwise alternative brands of **equal** and **approved** quality will be accepted.

5. Should the sub-contractor install any material not specified here in before receiving **written approval** from the Project Manager, the sub-contractor shall remove the material in question and, **at his own cost**, install the proper material.

6. The grand total of prices in the Summary of Volume 1 must be carried forward to the **Form of Tender for the tender to be deemed valid**.

7. The Bills of Quantities are divided generally into three sections:-

   a. **Contractual Requirements – Bill 1**

      Sub-contractors contractual requirements as called for the bill of quantities shall be priced and included in the tender. However the Tenderer is free to include and price any other items he deems necessary taking into consideration conditions he is likely to encounter on site.

   b. **Installation Items – Other Bills**

      The brief description of the items in these Bills of Quantities should in no way modify or supersede the detailed descriptions in the contract Drawings, conditions of contract and specifications. The unit of measurements and observations are as per Volume 1 or as indicated in the Bills of Quantities.

   c. **Summary**

      The summary contains tabulation of the separate parts of the Bills of Quantities carried forward with provisional sum, summary volume included. The sub-contractor shall insert his totals and enter his grand total tender sum in the summary of prices of Volume 1.
6.2. BILLS OF QUANTITIES
### SECTION D.W. (I) TITLE: PRELIMINARIES & CONTRACTUAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<th>Rate</th>
<th>KShs.</th>
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<td><strong>CONTRACTUAL REQUIREMENTS</strong></td>
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<tr>
<td>A</td>
<td>Preparation of working drawings, printing and distribution.</td>
<td>Sum</td>
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<td>B</td>
<td>Preparation of ‘As Installed Drawings”, printing and distribution as specified.</td>
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<td>Drawings to include:</td>
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<td>(a) Blue Prints - 4 sets of each.</td>
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<td>(b) AutoCAD on CD – 2 No.</td>
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<td>(c) Operational Instructions, manuals and test certificates</td>
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<td>C</td>
<td>Allow <strong>Kshs. 4,200,000.00</strong> Provisional sum for overseas factory inspection to cater for 6 No. persons (Client Rep- 1 No., SDPW Mechanical Engineer – 1, No. SDPW Technical – 1 No., User Departments Reps – 2 No., Consulting Mechanical Engineer – 1 No.) for Chillers and Air Handling Units</td>
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<td>4,200,000</td>
<td>4,200,000</td>
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<td>D</td>
<td>Any other item necessary to complete the installations in this section (please state)</td>
<td>Sum</td>
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Total carried to Summary page
## SECTION D.W. 1.0: CHILLERS

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<td>BASEMENT</td>
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<td>A.</td>
<td>Supply and deliver to site equipment as specified and approved, complete with controls and necessary accessories. <strong>AIR-COOLED CHILLER</strong> The chiller/heat pump multi-tube 6 pipes mainly include is used for the simultaneous production of chilled and hot water in two independent hydroid circuits and one domestic water circuit. The unit is able to simultaneously satisfy the demand for hot and cold water through a system that does not require seasonal switching. Each circuit works with a variable speed drive semi-hermetic screw compressor using R134a, two shell and tubes heat exchangers and a source side coil heat exchanger shared by both circuits. The cooling power is 982 Wc; the heating low temperature power is 931 kW. The system is equipped with a screw inverter technology. To produce domestic hot water an additional system is integrated inside the chiller/heat pump; the second stage overheated system allows to produce hot water up to 78°C with a total heating high temperature power of 279 cwt.</td>
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<tr>
<th>Capacity (NOMINAL)</th>
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<tr>
<td>Compressor</td>
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**EAKIP** Total carried to next page

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<table>
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<tr>
<td></td>
<td><strong>CHILLED WATER SYSTEM</strong></td>
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<td><strong>CHILLED WATER PIPE</strong></td>
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<td></td>
<td>Carbon Steel schedule 40 pipes to BS /ASME Stds, including fixing and jointing.</td>
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**CHILLED WATER SYSTEM**  
**CHILLED WATER PIPE – CONT’**

**TWO WAY REGULATING VALVE**  
Supply and Installation of Two Way Regulation Valve KSB BOA Control (or equivalent) including, fittings, electrical connections, connection to the pipes, insulation, and all expenses and charges, to perform the works as stated in Mechanical Specifications.

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**VOL 4.2/95**
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<td>Unit</td>
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<td>Rate</td>
<td>KShs.</td>
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<tr>
<td>Chiller Water Pumps.</td>
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<tr>
<td>Supply, Installation and commissioning of &quot;Close-coupled&quot; Centrifugal Pump including base, motor, impeller, sealing, flexible jolt, casing, valves, fittings, insulations, including connection to BMS for alarm and operation state, including electrical connection, connection to the pipes, and all expenses and charges, to perform the works as stated in Mechanical Specifications and P&amp;I Diagrams</td>
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<tr>
<td>A</td>
<td>Flow rate of 25m³/h at 150kPa two (2) pump system with duty standby/alternate. (PW01)</td>
<td>No.</td>
<td>1</td>
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<tr>
<td>B</td>
<td>Flow rate of 115m³/h at 150kPa three (3) pump system with duty standby/alternate. (PW02)</td>
<td>No.</td>
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<td>C</td>
<td>Flow rate of 135m³/h at 150kPa two (2) pump system with duty standby/alternate. (PW03)</td>
<td>No.</td>
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<td>D</td>
<td>Flow rate of 45m³/h at 150kPa two (2) pump system with duty standby/alternate. (PW04)</td>
<td>No.</td>
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<td>E</td>
<td>Flow rate of 5m³/h at 150kPa two (2) pump system with duty standby/alternate. (PW05)</td>
<td>No.</td>
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<td>F</td>
<td>Flow rate of 170m³/h at 80kPa two (2) pump system with duty standby/alternate. (PW06)</td>
<td>No.</td>
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<tr>
<td>G</td>
<td>Flow rate of 160m³/h at 85kPa two (2) pump system with duty standby/alternate. (PW07)</td>
<td>No.</td>
<td>2</td>
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<tr>
<td>H</td>
<td>Flow rate of 31m³/h at 80kPa two (2) pump system with duty standby/alternate. (PW08)</td>
<td>No.</td>
<td>2</td>
<td></td>
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<tr>
<td>I</td>
<td>Hot Water Calorifier, to come complete with heat exchanger, controls and accessories for heat-recovery from chilled water Air Conditioning System. Tenderers to allow for all piping, cabling and integration with HVAC system as may be required.</td>
<td>No.</td>
<td>2</td>
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<tr>
<td>EAKIP</td>
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### SECTION D.W. 2.0: AHUs

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<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
</thead>
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<tr>
<td>AHU SIDE BY SIDE TYPE</td>
<td>Outdoor AHU side by side type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanized steel. Insulation on injected polyurethane average density 45 kg/m³. With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board.</td>
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<td></td>
<td>Other installations and/or equipment are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international certification. The side by side AHU will be placed under a deck and the maximum height of both sections (return and supply) must not exceed 1 meter.</td>
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<tr>
<td>AHU-12</td>
<td>Flow rate of 9,000 m³/h with post heating coil.</td>
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<td>Item</td>
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<td></td>
<td><strong>AHU continued</strong></td>
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<tr>
<td>A</td>
<td>AHU-14. Flow rate of 8,000 m³/h with post heating coil.</td>
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<td>No. 1</td>
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<tr>
<td>B</td>
<td>AHU-15. Flow rate of 3,000m³/h without post heating coil.</td>
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<td></td>
<td>No. 1</td>
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<tr>
<td>C</td>
<td>AHU-05, 06, 07 and 08, as above but with a flow rate of 3,000m³/h for operating theatres.</td>
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<td>No. 2</td>
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<tr>
<td>D</td>
<td>AHU-10, as above but with a flow rate of 10,000m³/h for operating theatres.</td>
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<td>No. 0</td>
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<td>EAKIP</td>
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</table>
AHU OVERLYING TYPE
Outdoor AHU overlying type is mainly composed by: self-supporting frame with extruded section bars in double-wall aluminium camera for recessed screws. Section bar thickness 40 mm - Extruded gasket on panel and rounded interior. Double-wall sheet metal panels thickness 50 mm suitable for outdoor installation. Internal on AISI 304 stainless steel, external on plastic-coated galvanized steel. Insulation on injected polyurethane average density 45 kg/m³. 
With aluminium profile base frame. The base-plate shall be provided with spring shock-isolating mountings. The return section will be provided with: prefilter cleanable; centrifugal electric fan with double inlet and motor, inverter; silencers for return air; return air damper aluminium material; sand trap filter at the inlet. Certification.
The supply section will be provided with: prefilter cleanable; bag filters rigid bag type; heating/cooling coil; electrical steam humidifier; droplet eliminator; heating coil; centrifugal electric fan with double inlet and motor, inverter; damper; silencers for supply air. It is included the protection canopy over the AHU. On board control system complete of electrical panel, thermostat, pressure probe, temperature probe, humidity probe, differential pressure switch. Also included the protection cabinet for servo actuated valves and control board. Other installations and/or equipment are included to provide the system running as shown in the annex drawings. All equipment shall be specified to carry CE mark or equivalent international certification. All equipment shall be specified to be EUROVENT or equivalent international.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
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<th>Rate</th>
<th>KShs.</th>
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<tr>
<td>A</td>
<td>AHU-01, 02 and 09 with a flow rate of 14500m³/h, HEPA H14 and post heating coils.</td>
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<tr>
<td>Item</td>
<td>Description</td>
<td>Unit</td>
<td>Qty</td>
<td>Rate</td>
<td>KShs.</td>
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<tr>
<td><strong>AHU continued</strong></td>
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</tr>
<tr>
<td>A</td>
<td>AHU-03 and 04 with a flow rate of 14500m³/h and post heating coils.</td>
<td>No.</td>
<td>2</td>
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</tr>
<tr>
<td>B</td>
<td>AHU-11. Flow rate of 4,000m³/h.</td>
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<tr>
<td>C</td>
<td>AHU-03 and 04 with a flow rate of 8000m³/h and post heating coils. (Sterilization)</td>
<td>No.</td>
<td>2</td>
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<tr>
<td><strong>STEAM HUMIDIFIER</strong></td>
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<tr>
<td>D</td>
<td>It’s mainly equipped with: feed tank; conductivity meter; thermal protector relay to protect against excess heater temperature; solid state relay to modulate steam flow-rate; level sensor to guarantee the complete heater immersion; main control board; cylinder AISI304 steel lined with heat insulation. Drain pump. The steam humidifier produces non-pressurized steam using heating elements immersed in the water contained in a cylinder. To achieve uniform distribution of the heat flow, the heating elements, which are electrically insulated from the water, are covered in an aluminium casting. The heaters must be completely immersed in the water at all times, to avoid overheating. Immersed heater humidifiers thus require level sensors to ensure complete heater immersion, as well as components (solid state relays) to modulate the quantity of heat delivered to the water so as to precisely control steam flow-rate.</td>
<td>No.</td>
<td>6</td>
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<tr>
<td>E</td>
<td>13kg/h steam generator with power consumption of 10kW issued with AHUs with a flow rate of 3,000 - 4,000m³/h.</td>
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<td>F</td>
<td>40kg/h steam generator with power consumption of 30kW issued with AHUs with a flow rate of 8,000 - 10,000m³/h.</td>
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<tr>
<td>G</td>
<td>53kg/h steam generator with power consumption of 40kW issued with AHUs with a flow rate of 8,000 - 14,500m³/h.</td>
<td>No.</td>
<td>1</td>
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<tr>
<td>H</td>
<td>53kg/h steam generator with power consumption of 40kW issued with AHUs with a flow rate of 16,000m³/h.</td>
<td>No.</td>
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<td>Unit</td>
<td>Qty</td>
<td>Rate</td>
<td>KShs.</td>
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</tr>
<tr>
<td>A</td>
<td>CEILING FILTER SYSTEM FOR OPERATING ROOMS</td>
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<tr>
<td></td>
<td>Laminar flow ceiling will be installed in all operating theatre and it is mainly composed by: 1 laminar airflow ceiling system with load-bearing torsion-stiffened outflow, clean-room-side structure as filter-frame section from extruded anodized aluminium profile, large surface laminar fabric with minimal ridging, stable flow-optimised extruded anodized aluminium profile frame, fastened with a screw less fitting to the filter frame section, narrow ridges to minimize induction, perfect hygienic lights lead through the disperser with minimized blind surfaces, double-seal system filter assembly, pre-filtered air side structure; 2 integrated air recycling ceiling units for each operating theatre with a total of 6 integrated fan units with fluff guard of robust woven polyester fabric, easy to disassemble, screw less fitting, with integrated F7 pre-filter, and soundproofed anodised aluminium housing, connected via anodised aluminium lateral input channels set at a distance to the closed fan units and are completely pre-wired at a central interconnecting station where the incoming power supply link and the control/signalling line is then connected; 2 intake suction channels with range of possible positions. Laminar airflow ceiling with surrounding ceiling bearing angled brackets of powder-coated RAL 9010 aluminium to connect to the existing ceiling.ADMECO or equivalent.</td>
<td>No</td>
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<td><strong>AIR DUCTS (RIGID FOAM)</strong></td>
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<td>Supply and installation of Rigid foam type ducts in pre-insulated aluminium, they will be constructed using Piral HD Hydrotec panel or equivalent with antibacterial treatment, 200 µm (external side) embossed al/pur/200 µm (internal side) smooth antibacterial al o equivalent sandwich panels with the following characteristics: environmentally friendly sandwich panel made of a rigid polyurethane insulating foam minimum thickness 30 mm, including access door (for inspection and cleaning according EN standard), accessories and all expenses and charges to perform the works as stated in Mechanical Specifications and P&amp;I Diagrams. Material must be autoextinguishing certified class 0-1.</td>
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<td>LM</td>
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<td>LM</td>
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<td>250mm Dia</td>
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<td><strong>FLEXIBLE DUCTS</strong></td>
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<td>Supply and Installation of flexible duct including supply and fixing of the duct in the works,</td>
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<td></td>
<td>fittings, connection, brackets flexible joints, and all expenses and charges, to perform the works</td>
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<td>as stated in Mechanical Specifications.</td>
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<td></td>
<td>Supply of un-insulated with fibre glass Flexible Duct with vapour barrier and reinforcing metal</td>
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<td>helix.</td>
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<td>LM</td>
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<td></td>
<td><strong>MOTORIZED FIRE DAMPER</strong></td>
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<td>Supply and Installation of Fire damper 120 min fire resistance including electric motor, fittings,</td>
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<td></td>
<td>thermal disconnect switch with fuse pre-set at 72°C for fire detection, single limit switch to</td>
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<td>indicate dumper position including electrical connections, connection to the ducts, insulations,</td>
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<tr>
<td></td>
<td>and all expenses and charges, to perform the works as stated in Mechanical Specifications.</td>
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<td>G</td>
<td>1000x400mm</td>
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<td>1000 x 550mm</td>
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<td>J</td>
<td>800 x 400mm</td>
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<td>Total carried to next page</td>
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</table>
### MANUALLY OPERATED VOLUME CONTROL DAMPERS

Volume control damper for duct mounting with facility for adjustment from outside duct as "Woods" to fit following duct sections 240 x 230mm. These to be of the opposed blade (OBD) type or equal and approved.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
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<tbody>
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</tr>
<tr>
<td>A</td>
<td>500x480mm ditto</td>
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<td>2</td>
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</tr>
<tr>
<td>B</td>
<td>500x530mm ditto</td>
<td>No.</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>C</td>
<td>500x580mm ditto</td>
<td>No.</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>D</td>
<td>500x630mm ditto</td>
<td>No.</td>
<td>6</td>
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<tr>
<td>E</td>
<td>200 x 200mm</td>
<td>No.</td>
<td>43</td>
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<tr>
<td>F</td>
<td>200 x 250mm</td>
<td>No.</td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td>G</td>
<td>200 x 300mm</td>
<td>No.</td>
<td>5</td>
<td></td>
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</tr>
<tr>
<td>H</td>
<td>200 x 400mm</td>
<td>No.</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>200 x 600mm</td>
<td>No.</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>J</td>
<td>300 x 250mm</td>
<td>No.</td>
<td>9</td>
<td></td>
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</tr>
<tr>
<td>K</td>
<td>300 x 300mm</td>
<td>No.</td>
<td>7</td>
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<tr>
<td>L</td>
<td>300 x 400mm</td>
<td>No.</td>
<td>11</td>
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<tr>
<td>M</td>
<td>300 x 500mm</td>
<td>No.</td>
<td>3</td>
<td></td>
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<tr>
<td>N</td>
<td>300 x 700mm</td>
<td>No.</td>
<td>2</td>
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</tr>
<tr>
<td>O</td>
<td>400 x 600mm</td>
<td>No.</td>
<td>3</td>
<td></td>
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<tr>
<td>P</td>
<td>400 x 700mm</td>
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<tr>
<td>Item</td>
<td>Description</td>
<td>Unit</td>
<td>Qty</td>
<td>Rate</td>
<td>KShs.</td>
</tr>
<tr>
<td>------</td>
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<td><strong>Total from previous page</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>VAV CONTROLLERS - TVZ AIR SUPPLY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAV</td>
<td>controllers (TROX VARYCONTROL VAV Terminal Boxes TVZ/TVA or equivalent) provide volume flow control for variable air volume systems for supply air or extract air. The box consists of a casing with circular high pressure and rectangular low pressure duct connections, integral acoustic silencer, averaging differential pressure grid for volume flow measurement. All the pressure, flow and temperature control regulating systems (sensors, actuators, electronics, etc) to allow a proper operation has to be included in the scope of the work. Boxes has to be supplied with hot water reheat coils including regulating servoactuated valve. VAV boxes has to be provided with control components to suit the control specification. A differential pressure controller (Belimo VRP-STP - Trox BG3 model or equivalent) combined with a membrane differential pressure transducer, is to be provided to ensure the room pressure control. Including connection to BMS for remote monitoring and control, electrical connection, engineering. Including accessories and all expenses and charge to perform the works as stated in mechanical specifications an P&amp;I Diagrams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>ø355mm</td>
<td>No.</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>ø300mm</td>
<td>No.</td>
<td>3</td>
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</tr>
<tr>
<td>C</td>
<td>ø250mm</td>
<td>No.</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>D</td>
<td>ø200mm</td>
<td>No.</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>ø180mm</td>
<td>No.</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>ø125mm</td>
<td>No.</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>EAKIP</td>
<td>Total carried to next page</td>
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<tr>
<td>Item</td>
<td>Description</td>
<td>Unit</td>
<td>Qty</td>
<td>Rate</td>
<td>KShs.</td>
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<td>------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>A</td>
<td><strong>Total from previous page</strong>&lt;br&gt;<strong>Level +1 AIR DIFFUSERS</strong>&lt;br&gt;Supply and installation of stainless steel Extraction grilles for operating theatre SAGI COFIM type DEC-S or similar. The grilles mod. &quot;DEC&quot;, which are specific for controlled contamination environments. Structure: AISI 304 Stainless steel, Panel: AISI 304 stainless steel; including AISI 304 stainless steel plenum, filter G4 efficiency, flow adjustment damper, accessories and all expenses and charges to perform the works as stated in Mechanical Specifications and P&amp;I Diagrams. Supply and installation of Terminal hoods for complete HEPA H14 filters, these will be SAGI COFIM type DIF.P or similar; DIF.P WT High induction diffuser terminals are made of an anodized aluminium frame which holds the DELTA series, including accessories and all expenses and charges to perform the works as stated in Mechanical Specifications and P&amp;I Diagrams.</td>
<td>No. 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Supply and installation of Aluminium Supply Circular Swirl Diffuser including flow adjustment device, galvanised steel plenum, fittings, connection to the ducts and all expenses and charges, to perform the works as stated in Mechanical Specifications.</td>
<td>787 x 787 x 445mm high</td>
<td>No. 85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>330 x 330 345mm high</td>
<td>No. 60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>635 x 635 x 365mm high</td>
<td>No. 98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td><strong>Level 0 and -1 AIR DIFFUSERS</strong></td>
<td>ø225mm</td>
<td>No. 20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td><strong>Level 0 and -1 AIR DIFFUSERS</strong></td>
<td>ø250mm</td>
<td>No. 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td><strong>Level 0 and -1 AIR DIFFUSERS</strong></td>
<td>ø300mm</td>
<td>No. 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td><strong>Level 0 and -1 AIR DIFFUSERS</strong></td>
<td>ø350mm</td>
<td>No. 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Ditto but 600x600mm grilles</td>
<td>ø400mm</td>
<td>No. 160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Ditto but 600x600mm grilles</td>
<td>600x600mm</td>
<td>No. 140</td>
<td></td>
<td></td>
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<td></td>
<td><strong>Total carried to main collection</strong></td>
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</tbody>
</table>
## MECHANICAL VENTILATION

### (TOILET/KITCHEN & LAUNDRY SUPPLY & EXTRACT FANS)

Supply, deliver and install the following equipment. The fans to be complete with attenuators up and downstream.

Supply/extract fans. The fan shall be as "SOLAR & PALAU THGT" complete with a direct drive axial flow fan or equal and approved.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3,000m³/h against a static pressure of 250Pa.</td>
<td>No</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>4,500m³/h against a static pressure of 250Pa.</td>
<td>No</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>5,500m³/h against a static pressure of 250Pa.</td>
<td>No</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>8,000m³/h against a static pressure of 250Pa.</td>
<td>No</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Axial fan capable of extracting 2,000m³/h against a static pressure of 100Pa. The fan shall be as &quot;SOLAR &amp; PALAU THGT&quot; complete with a direct drive axial flow fan or equal and approved.</td>
<td>No</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total carried to next page**
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Total from previous page</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply, deliver and install the following equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Duct Work</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Galvanised sheet steel ductwork inclusive of all joints, bends, bracing,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>gaskets, supports, stiffeners, turning vanes, splitters, vapour seals,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>access hatches at every 3000mm and change of direction and any other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>equipment for completion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Straight Lengths</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rectangular Sections</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>A</td>
<td>Material thickness 0.6mm</td>
<td>SM</td>
<td>60</td>
<td></td>
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</tr>
<tr>
<td>B</td>
<td>Material thickness 0.8mm</td>
<td>SM</td>
<td>20</td>
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<tr>
<td>C</td>
<td>Material thickness 1.0mm</td>
<td>SM</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Toilet Grilles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply and Installation of Disc Extraction Adjustable Valve including</td>
<td>No.</td>
<td>168</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>fittings, connection to the ducts and all expenses and charges, to perform</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the works as stated in Mechanical Specifications.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>ø100mm</td>
<td>No.</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>ø125mm</td>
<td>No.</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>ø150mm</td>
<td>No.</td>
<td>27</td>
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<tr>
<td></td>
<td><strong>Kitchen Grilles</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Supply and Installation of Aluminium Extraction Grill including flow</td>
<td>No.</td>
<td>25</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>adjustment device, galvanised steel plenum, fittings, connection to the</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>ducts and all expenses and charges, to perform the works as stated in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Specifications.</td>
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</tr>
<tr>
<td>G</td>
<td>300 x 300mm</td>
<td>No.</td>
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</tr>
<tr>
<td>H</td>
<td>500 x 500mm</td>
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<td>2</td>
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<tr>
<td>I</td>
<td>600 x 600mm</td>
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<td>15</td>
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<tr>
<td>J</td>
<td>450 x 450mm</td>
<td>No.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>500 x 450mm</td>
<td>No.</td>
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VOL 4.2/111
### SECTION D.W. 5.0: VRF

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td><strong>UPS &amp; CED ROOMS AIR CONDITIONING SERVICES</strong>&lt;br&gt;Supply, install, test and commission the following air conditioning units. The units must be wired for automatic resetting in the event of power failures. VRV/VRF System”, inverter heat pump type air conditioning system or equal and approved comprising out/indoor units including supports and all safety devices of high pressure switch, fan motor driver overload protector, inverter overload protection over current relay and PCB fuse all as described here below:- prefered models are Trane,TOSHIBA,YORK, Carrier, Daikin and GENERAL.&lt;br&gt;&lt;br&gt;<strong>The Outdoor Units</strong>&lt;br&gt;These shall be modular units. The compressor to be of the hermetically sealed scroll type with power supply of 3ph, 380 – 415V, 50Hz supply. Compressor to be for use with CFC FREE refrigerant. (<strong>Note that R22 and any other ozone depleting refrigerant will not be acceptable</strong>). The unit shall be complete with function unit to manufacturer’s specification, safety devices including HPS, fan driver overload protector, over current relay, inverter overload protector, PC Board fuse, Building Management System (BMS) interface etc.</td>
<td>No</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>33.5kW cooling only</td>
<td>No</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>B</td>
<td>22.4kW cooling only</td>
<td>No</td>
<td>2</td>
<td></td>
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<tr>
<td>C</td>
<td>Outdoor unit multi-connection piping kits. Outdoor unit bracket to approval.</td>
<td>No</td>
<td>2</td>
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**EAKIP** Total carried to next page
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<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
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<tbody>
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<td></td>
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</tr>
<tr>
<td></td>
<td>11.2kW Ceiling concealed ductable unit complete with necessary accessories and mounting to the slab. Units to be complete with all ducting, duct transition pieces, grilles and diffusers</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Supply and install refrigeration copper pipe work complete with 25mm Armoflex Rubber Insulation for suction/liquid line including all the fittings, 'Y' Joints, Distributors etc. size 13mm to 35mm</td>
<td>No.</td>
<td>10</td>
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<td>280</td>
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**SECTION D.W. 6.0: BMS**

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<th>Item</th>
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<tbody>
<tr>
<td></td>
<td><strong>Building Management System</strong></td>
</tr>
<tr>
<td></td>
<td>Provision of all necessary hardware and software including, but not limited</td>
</tr>
<tr>
<td></td>
<td>to contacts, instrumentation, wiring and conduits to accomplish the control</td>
</tr>
<tr>
<td></td>
<td>and control sequence for heating, ventilating and air conditioning system</td>
</tr>
<tr>
<td></td>
<td>as per the drawings and specification for the following equipment.</td>
</tr>
<tr>
<td></td>
<td>(i) Chillers</td>
</tr>
<tr>
<td></td>
<td>(ii) Chilled Water pumps</td>
</tr>
<tr>
<td></td>
<td>(iii) Hot water pumps</td>
</tr>
<tr>
<td></td>
<td>(iv) Air handling units</td>
</tr>
<tr>
<td></td>
<td>(v) VAV</td>
</tr>
<tr>
<td></td>
<td>(vi) Fan coil units</td>
</tr>
<tr>
<td></td>
<td>(vii) Air extract fans</td>
</tr>
<tr>
<td></td>
<td>(viii) Fire and medical gas alarms</td>
</tr>
<tr>
<td></td>
<td>(ix) Elevators</td>
</tr>
<tr>
<td></td>
<td>(x) UPS</td>
</tr>
<tr>
<td></td>
<td>(xi) Isolation Rooms pressure sensors</td>
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**Lot 1**

<table>
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**Total carried to main collection page**
### SECTION D.W. 7.0: FAN COIL UNITS

<table>
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<tr>
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<th>Qty</th>
<th>Rate</th>
<th>KShs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>The Indoor Units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chilled water fan coil units complete with filters, wired remote control, drain up kit, and wiring to the power distribution.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.05kW chilled water fan coil unit c/w wired remote controls Key pad, and selector BS boxes as &quot;Daikin FWW500VC&quot; or equal and approved.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>A</td>
<td>No. 13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>600 X 600 diffusers</td>
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<td>36</td>
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<td>D.W.4</td>
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7. PART G: TECHNICAL SCHEDULE

7.1. Documentation Requirements

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7.2. TECHNICAL SCHEDULE

The tenderer **MUST SUBMIT** comprehensive manufacturer’s technical brochures and performance details for all items listed in this schedule (fill forms attached).

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<th>ITEM No.</th>
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<tr>
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8. PART H: DRAWING SCHEDULE:

8.1. DRAWING SCHEDULE:

As shall be provided during project implementation.