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MECHANICAL SERVICES SCHEDULE OF WORKS & TENDER SUMMARY

Project:

MECHANICAL VENTILATION SYSTEM REPLACEMENT

CHARTER HALL, OKEHAMPTON OKEHAMPTON TOWN HALL

Document Ref:

OKE-3DE-XX-XX-SP-M-57-0006

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1.0 INTRODUCTION

The following document sets out the schedule of works for the mechanical services installations for the **PROPOSED MECHANICAL VENTILATION SYSTEM REPLACEMENT**, at **CHARTER HALL, OKEHAMPTON, OKEHAMPTON TOWN HALL**.

The purpose of this document is to provide technical details of the proposed mechanical & electrical services installations only, and therefore does not set out contractual arrangements, sequencing of works or timescales for the work. These items should be discussed with the appointed Main Contractor should your Tender be successful.

This document should be read in conjunction with the complementary mechanical services drawings, equipment schedules, and supplementary information detailed within the Appendices of this document.

A Summary of Tender document is provided for the Mechanical Services installation within the Appendices of this document. This should be completed by the Mechanical Contractor when Tendering the works and **returned directly via email to the project Architect – Mark Kemp, Place Architects,** people@placearchitects.co.uk.

Should you have any queries during the Tender period, please direct these to the Mechanical Engineer via email to James Davies, 3de Consulting Ltd - jamesd@3deconsulting.co.uk We (3de) will endeavour to answer any queries in a timely manner.

2.0 CONTRACT CONDITIONS & PRELIMINARIES

2.1 CONTRACT PARTICULARS

The mechanical services installations will comprise of the provision of a replacement mechanical ventilation system as depicted on the Tender drawings and detailed herein.

The successful Mechanical Contractor shall be appointed by the Main Contractor for the overall project and enter into an intermediate named sub-contract Tender agreement as required.

2.2 NOTICE TO TENDERERS

The Summary of Tender document found in the Appendices of this document should be completed by the Mechanical Contractor when Tendering the works and **returned directly via email to the project Architect – Mark Kemp, Place Architects,** people@placearchitects.co.uk.

Tenders qualified in any way will be liable to rejection and Tenders not submitted in accordance with the procedures, not completed in its entirety, or Tenders received after the time stated may be liable to rejection.

It must be noted that the successful Contractors will not be permitted to take possession of the site until contracts are signed.

Where an appropriate British Standard Specification or British Standard Code of Practice issued by the British Standard Institution is current at the date of the Tender, all goods and materials used or supplied, and all workmanship shall be in accordance with that Standard.

The Contractor shall comply with all relevant legislation concerning Health and Safety at Work.

It is recommended that the Contractors Tendering for these works visits site before submitting their prices to ensure they fully understand the extents and conditions of the proposed works. No claim in respect of want of knowledge will be considered.

2.3 LOCATION OF THE WORKS

The Works are to be undertaken at the following premises:

CHARTER HALL, OKEHAMPTON TOWN HALL, FORE STREET, OKEHAMPTON, EX20 1AA.

Before Tendering, the Tenderer must examine the drawings and Conditions of Contract and visit the site to satisfy himself as to all local conditions affecting the execution of the Contract, including accessibility of the site, the full extent and character of the proposed works, the nature of the ground, the supply of and conditions affecting labour and materials and the execution of the contract generally, as no claim on the grounds of want of knowledge in such respects will be entertained.

2.4 EXTENT OF WORKS

The extent of the works 'Works' covered by this document include the following items as described herein later, and as detailed on the Contract Drawings which are also enumerated later.

2.5 TENDER DRAWINGS

The Tender drawings as scheduled within the Appendices of this document will comprise the Contract Drawings.

The drawings of the works specified have been prepared as a basis for Tendering only and to assist the Contractors in the preparation of their Tenders. It must be clearly understood that they diagrammatically indicate the most suitable position of equipment, pipe runs, conduits, etc., and that before installation takes place, all final positions of equipment etc., must be agreed and co-ordinated on site.

The drawings of the works specified form an integral part of this Specification document, and any work shown on the drawings but not detailed in the Specification and vice versa, must be included. The whole of the works must be to the entire satisfaction of the Project Engineer (3de Consulting Ltd).

2.6 BUILDERS WORK

The Mechanical Contractor is to mark location of holes required for passage of services to run through walls throughout building.

The Main Contractor to drill holes and make good where necessary.

2.7 ORDER OF WORKS

The Mechanical Contractor will be given possession of the site immediately after signing the Contract. A completion certificate will be issued upon completion of the whole contract.

The Mechanical Contractor shall allow for all necessary labour to achieve the Main Mechanical Contractor programme. Works will generally be carried out during normal working hours. The programme of works is to be agreed with the Main Contractor.

The area of works must be left in a safe condition at the end of each day and all services left operational unless otherwise agreed with the Main Contractor.

2.8 MANNER OF EXECUTION

The Mechanical Contractor will be required to agree and adhere to a programme for the works with the Client / Architect / Main Contractor / Project Engineer.

The Mechanical Contractor will be deemed to have allowed for the attendance of a representative at all site meetings, and all meetings held at the offices of the Architect or local to site.

The representative shall be a responsible person fully authorised to make, and/or agree to any decisions regarding alterations, programming, expenditure of monies etc.

The work shall be carried out to the satisfaction of the Project Engineer or his representative and in such sections and manner to suit the programme drawn up by and agreed with the Client.

The Mechanical Contractor shall take all reasonable precautions to prevent nuisance or inconvenience to the Client, or the surrounding Tenants.

2.9 LABOUR AND SUPERVISION

Experienced workmen only shall be employed, and these shall be under the supervision of a competent representative, who shall be capable of executing the works in a competent manner.

Such workmen and representative shall remain on the works at all times that the installations are being carried out.

The Mechanical Contractor shall maintain on site at all times sufficient labour to ensure that all materials are installed in correct sequences having due regard to the progress of the Contract.

The Mechanical Contractor shall provide and ensure that his employees wear and display at all times such identification as may be specified by the Client. Such identification must be available for inspection by the Tenants / Project Engineer at all times during the provision of the service.

The Mechanical Contractor shall not sub-contract the whole or any part of the works without the prior written consent of the Project Engineer.

2.10 OVERTIME

Overtime will not be permitted except in unusual circumstances, and then only with the prior arrangement of the Tenants and with the permission of the Project Engineer. The Contractor shall allow in his Tender price to work however many days a week required in order to achieve the Main Mechanical Contractor completion date.

2.11 DAYWORKS

No charge or accounts for Dayworks or extra works will be allowed unless specifically ordered by the Project Engineer, in writing, before such work is commenced.

Daywork will be dealt with in accordance with the "Definition of Prime Cost of Dayworks" as published by the Royal Institute of Chartered Surveyors (R.I.C.S.) and the Electrical Mechanical Contractor Association (ECA). In all cases the percentage on-cost for plant, materials and labour shall be those entered by the Tenderer of the Schedule of Rates for Daywork.

Vouchers certifying time and materials for Daywork are to be submitted to the Project Engineer during the week following the execution of the work.

2.12 SAFETY, HEALTH AND WELFARE

The Mechanical Contractor shall comply in all respects with the requirements of all current safety, health and welfare regulations relating to the Construction Industry.

2.13 C.D.M. REGULATIONS

The Mechanical Contractor should note that this specification for the intended "Construction Work" has been compiled with the knowledge of current construction methods and working practises and in the opinion of the specifier renders the proposed project as 'notifiable' to the HSE.

The Contractor will be required to comply and co-operate with the appointed principal Mechanical Contractor safety arrangements.

2.14 PROTECTION OF WORKS

The Mechanical Contractor shall ensure that every care is taken of the Contract Works, materials and equipment. Suitable covering and protection shall be applied where damage is likely to result due to the weather, frost etc., or due to carelessness, theft, rough treatment, dust, grit, or injury to other ways.

The Mechanical Contractor shall accept responsibility until materials and equipment have been fully, finally, and properly incorporated into the Contract Works.

The Mechanical Contractor are to leave all unfinished work at the end of each day's working so as to obviate any risk or danger to the occupiers of the dwellings concerned.

2.15 PROTECTION OF PROPERTY, FIXTURES AND FITTINGS

The Mechanical Contractor will be expected to take all necessary precautions to avoid damage to existing fixtures and fittings.

The Mechanical Contractor shall allow for carefully covering up and protecting fixtures, fittings, etc., during the course of the works, and for making good all damage occasioned by insufficiency of such protection. This protection shall include sealing off from the area of the works.

The Mechanical Contractor shall allow for cleaning all parts of the building affected by the works, inside and out, including removing stains, touching up decorations, and for leaving the whole of the works clean and tidy on completion, to the entire satisfaction of the Client.

The making good of any damage to any piece of equipment structure or surface is to be to the satisfaction of the Project Engineer, with the minimum requirement being to match existing.

2.16 DRAWINGS, SPECIFICATION AND EQUIPMENT SCHEDULES

Drawings of the works specified have been prepared by the Project Engineer as a basis for Tendering. It should be noted that they are diagrammatic and that it will be necessary for the Mechanical Contractor to provide their own Working Drawings. These working drawings shall be submitted to the Project Engineer, Client and Design Team for comment.

No works may commence until working drawings have been commented upon by the Project Engineer and Design Team and amended to incorporate comments. Any works carried out prior to submission and comment of working drawings shall be entirely at the Contractor's risk and shall be subject to alteration if deemed necessary at no extra cost to the contract.

The drawings of the works specified are an integral part of this Specification document and any work shown on these drawings but not detailed in the Specification and vice versa must be included in the Tender Figure.

The Drawings, Specification and Equipment Schedules shall be read together. The Contractor shall include in the Tender for any item or instructions detailed in the Specification and on Schedules attached hereto, whether or not the item or instruction concerned is detailed on the drawings.

The Project Engineer and Client reserve the right to effect alterations to the positions of lighting fittings, switches, outlets, diffusers, etc. as required by ceiling and partition layouts and site requirements. Such alterations shall be carried out without extra charge providing there is no additional material involved and the instructions are given before the work proceeds.

Should any location query arise, it shall be addressed to the Design Team prior to installation.

Should relocation of any item be necessary where a relevant query has not been raised, the associated cost shall be borne by the Mechanical Contractor.

Should there be any discrepancy between the Standard Specification sections and Particular Specification section, the clauses detailed within the Particular section shall take precedence.

2.17 REFERENCE STANDARDS

Where reference standards are quoted in this document which have since been superseded or withdrawn, the most recent version of this reference standard is to apply.

3.0 MECHANICAL SERVICES – PARTICULAR REQUIREMENTS

3.1 GENERAL DESCRIPTION OF WORKS

The works described within this section of the Specification document relate to the Mechanical Services works associated with the **PROPOSED MECHANICAL VENTILATION SYSTEM REPLACEMENT**, at **CHARTER HALL, OKEHAMPTON, OKEHAMPTON TOWN HALL**.

All mechanical services distribution systems & equipment shall be installed by the Mechanical Contractor as detailed in this specification and on the associated drawings/schedules listed within the Appendices of this document.

The Mechanical Contractor shall fully co-ordinate with the Main Contractor and building restrictions in order to achieve a neat, symmetrical and accessible services arrangement with the respective available spaces.

3.2 CONTRACTOR'S RESPONSIBILITIES

The Mechanical Contractor will be responsible for the installation and correct operation of all the Mechanical Engineering Services in accordance with the details of this Specification, Associated Drawings, relevant British Standards, codes of practice and CIBSE guidelines.

3.3 MECHANICAL SERVICES SCOPE OF WORKS:

The mechanical services scope of works shall include but not be limited to the following:

- Strip out & removal of existing redundant Mechanical Ventilation Services
- Proposed supply, installation, testing & commissioning of new Mechanical Ventilation Services
- Re-instatement of existing Air Handling Unit (AHU)

The Mechanical Contractor should refer to the supplementary design drawings and relevant parts of this specification for the exact scope of works.

The following section details the scope of the mechanical works which are to be carried out by the Mechanical Contractor.

This section should be read in conjunction with all mechanical services equipment data sheets, mechanical services drawings, and all other relevant engineering specifications issued as part of the works information.

Prior to ordering equipment, the contractor shall submit complete technical submissions for all systems for approval by the Client and Engineer.

3.4 EXISTING MECHANICAL VENTILATION SERVICES

3.4.1 Existing Ventilation System Configuration

The existing mechanical ventilation system, serving the Charter Hall space, is provided via a single supply & extract air handling unit (AHU) located on the flat roof area above the toilets adjacent to the Charter Hall space.

The system was installed in January 2013 and despite requiring some minor repair works, it is in relatively good condition and working order.

A record drawing of the existing mechanical ventilation system layout can be found within *Appendix 4* of this document.

Figure 1 below shows a plan layout indicating the extent of the existing mechanical ventilation system plant installation on the existing flat roof area. The original image was taken using a drone mounted camera and was commissioned by Place Architects Ltd.

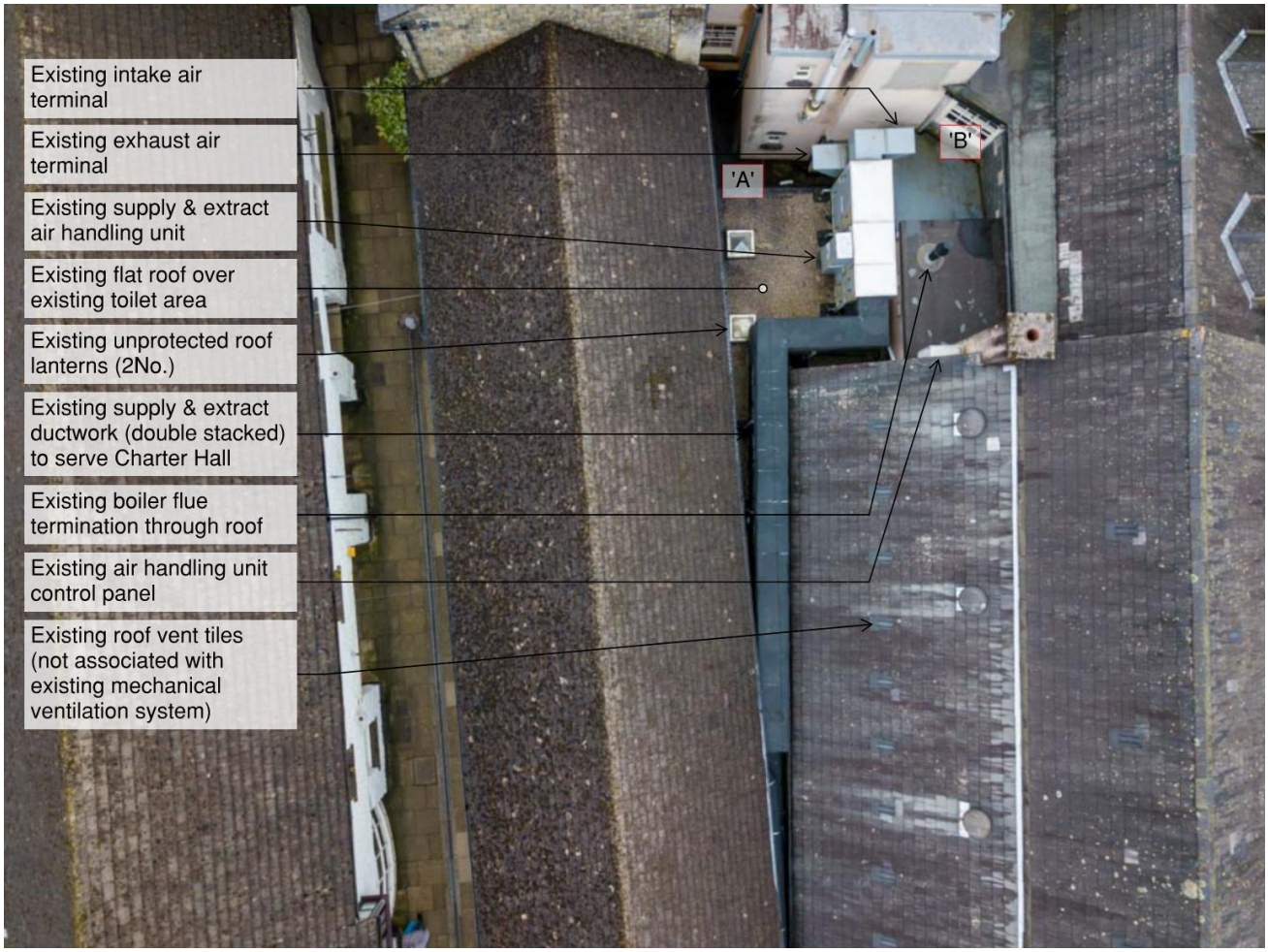


Figure 1 – Existing roof layout indicating extent of existing mechanical ventilation system plant installation (NTS)

The existing mechanical ventilation system serving the Charter Hall space is designed specifically to extract 'stale' air from the space, and to replace this extracted air with 'fresh' supply air.

The existing roof mounted supply & extract air handling unit (AHU) incorporates an extract fan which extracts the stale air from the space via a single wall mounted extract grille located at high level at the centre of the room.

Figure 2 – Existing wall mounted extract air grille at high level within Charter Hall space

From this grille position, the extract air is drawn to the AHU by the extract fan via a short run of extract ductwork. The extract air enters the air handling unit where it is passed across a plate heat exchanger which recovers heat energy from the extracted air which is used to pre-heat the incoming supply air to the space.

When the extract air has passed through the plate heat exchanger within the AHU, it is exhausted to atmosphere via a weatherproof cowl arrangement complete with bird guard.

'Fresh' Intake air is brought into the AHU via a supply fan. The intake air is also provided with a weatherproof cowl arrangement complete with bird guard. See *Figure 3* below:

Figure 3 – Intake & exhaust air weatherproof ductwork terminations complete with bird guards

As the intake air enters the AHU, it is passed across a plate heat exchanger which recovers heat energy from the extracted air which is used to pre-heat the incoming supply air to the space.

Figure 4 below shows a schematic representation of the existing AHU arrangement:

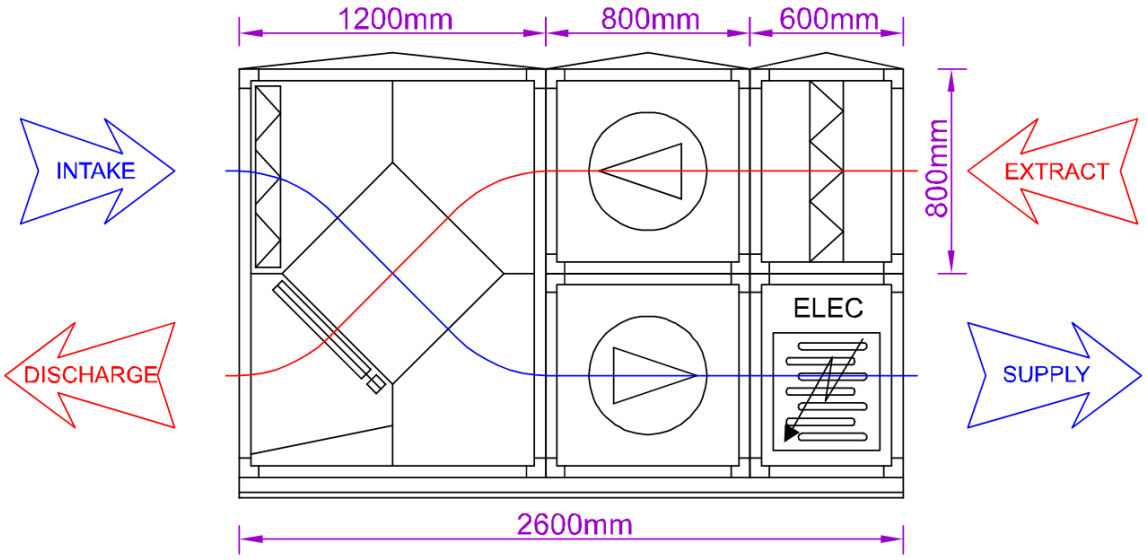


Figure 4 – Schematic representation of existing AHU arrangement (NTS)

To ensure that the supply air entering the space is at a sufficient temperature not to cause any discomfort to the users of the space, an electric heater is provided within the AHU to 'temper' the supply air. This ensures that during times of low external temperatures, the supply air entering the space will always be at a set minimum temperature (typically 16-18°C).

From the AHU, the 'tempered' supply air is ducted to the space via a short run of ductwork and is supplied into the space via 2No. existing wall mounted low level supply diffusers.

Figure 5 – Existing supply & extract ductwork (double stacked & insulated) on flat roof

Figure 6 - Existing wall mounted supply diffuser at low level within Charter Hall space

Despite the supply air being tempered, it should be noted that this is not the primary method of heating the space. The space is heated via a series of low-level wall mounted radiators which are controlled via a local wall mounted

thermostat/controller mounted above the existing fan controller. The radiators within the Charter Hall space are fed from a separate heating circuit served via a new boiler plant installation within the boiler plant room which is adjacent to the main stage area.

At the time of survey, it was confirmed that the existing heating system is in full working order and is being operated and controlled successfully.

The design volume of the existing system is 1.000 m^3/s. This figure is confirmed by the original 'Duct Traverse Sheet' which was produced as part of the initial commissioning of the system and can be found in *Appendix 2* of this document for reference. As such, it can be calculated that the existing ventilation system has been designed to provide mechanical ventilation within the Charter Hall space for a peak occupancy of 100 people.

3.4.2 Existing Ventilation System Operation

The existing ventilation system is provided with a local wall mounted touch panel controller ('Nuaire' 'Ecosmart' type). This controller is located to the side of the stage area adjacent to the main lighting switches and electrical distribution board for the space. *Figure 8* below shows the position of this controller highlighted with a red box:

The existing wall mounted controller is provided with a timeclock facility and also a duct mounted Carbon Dioxide (CO_2) sensor located within the return air ductwork to the air handling unit (AHU).

Therefore, the control of the unit should be relatively simple in that:

- System is primarily controlled via timeclock. I.e., unit will be 'on' within boundaries set on timeclock.
- System is also controlled via CO_2 sensor. I.e., system will be 'on' and running at a low level. As the level of CO_2 within the space increases (via users of the space exhaling), the system will 'ramp-up' in stages to provide the level of ventilation necessary to keep the level of CO_2 within the space between set targets.

As such, other than setting the timeclock, the installed ventilation system should run autonomously without any required additional user input.

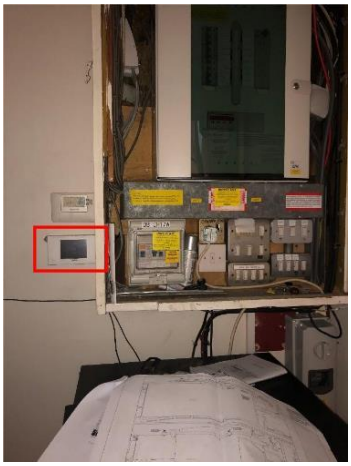


Figure 7 - Position of existing wall mounted fan controller serving Charter Hall space

3.4.3 Existing Ventilation System Access & Maintenance

As shown within *Figure 1* previously, the existing AHU is roof mounted on an existing flat roof above the existing toilet area.

Figure 8 – Existing AHU installation on flat roof area

There is no permanent method of access to the flat roof area and as such the only way to gain access is by using a temporary access ladder positioned at point 'A' shown on *Figure 1*.

There are 2No. existing roof lanterns on this flat roof area. These are unprotected.

To get to the rear of the AHU or the AHU controls enclosure, the only way to gain access is by climbing out of the existing sash window positioned at point 'B' *Figure 1*.

Figure 9 – Existing sash window access to flat roof area

Figure 10 - Existing AHU controls enclosure location

To get to the controls enclosure from this point, the operative must climb up onto a raised flat roof area above the existing boiler plant room.

As a result, access to the existing ventilation system plant is dangerous and not in line with current health and safety guidelines and recommendations.

In order to gain access to the plant, operatives must climb onto the flat roof area, where they are at risk of falling from the roof as there are no permanent guardrails in position. As the plant is difficult to access and maintain, it is likely that it is maintained and serviced less than is recommended.

To improve the access to the installed equipment, it is recommended that the Architect provide suitable guard rails to ensure safe access to the roof areas can be maintained.

3.4.4 Existing Ventilation System - Removals

It is proposed that the existing air handling unit (AHU) be retained. However, as the proposed works includes the resurfacing of the existing flat roof, the existing AHU is to be removed from the flat roof area. This is to be undertaken using a suitable crane as arranged by the Main Contractor. The Main Contractor shall also include for the safe indoor storage of the existing AHU for the duration of the works until it is re-instated.

The Mechanical Contractor shall ensure that the existing AHU is electrically isolated and disconnected from the existing ductwork system prior to removal by the Main Contractor. The Main Contractor shall allow access to the existing AHU throughout the duration of safe storage to the Mechanical Contractor to allow for the existing AHU to be thoroughly cleaned, repaired & re-commissioned prior to re-instatement on site. *Appendix 3* of document shows a quotation for the repair of the existing AHU. As some time has passed since the preparation of this quotation, it is unclear as to whether or not additional repair works are required to the AHU. As such, the Mechanical Contractor shall fully service the unit to determine if any other repairs are required as part of the proposed works.

The existing ductwork installation and the existing side-wall mounted supply diffuser & extract grille within the Charter Hall space are to become redundant. Therefore, these are to be removed & safely disposed of by the Mechanical Contractor. The Mechanical Contractor shall also arrange for the safe removal and disposal of the existing controls enclosure serving the AHU unless this is found to be serviceable.

3.5 PROPOSED MECHANICAL VENTILATION SERVICES

As described previously within this report, the existing air handling unit is to be re-instated to serve the Charter Hall space following completion of the new flat roofing works and new structural support works. The AHU is to be mounted on the new structural support in line with the Structural Engineer's recommendations by the Main Contractor. The Mechanical Contractor shall supervise these works to ensure that the existing AHU is installed in a suitable position to facilitate the new ductwork system installation.

Prior to the existing AHU being re-delivered and re-instated on site, the Mechanical Contractor shall ensure that the unit is fully cleaned, serviced, repaired, and in full working order. These works shall be undertaken off site and facilitated by the Main Contractor who will be responsible for the safe storage of the AHU as described previously.

When the existing AHU has been re-instated, new intake air & exhaust air ductwork terminations will be taken from the unit. These terminations will be complete with suitable new 45° square weatherproof self-supporting bird beak arrangements complete with bird mesh.

The existing controls enclosure serving the AHU is to be removed to make way for the new ductwork installation and replaced with new. If during the works the Mechanical Contractor finds that the existing Controls Enclosure & associated equipment is suitable for re-location, the Mechanical Contractor shall offer the Client a saving for re-locating this equipment against providing new.

From the existing AHU, new supply air & extract air ductwork will set-across the existing flat roof area and enter the Charter Hall roof void via the nearby gable end. The required builderswork to facilitate these duct entries including waterproofing shall be undertaken by the Main Contractor.

Within the roof void, the new supply air & extract air ductwork shall connect to a series of supply diffusers and extract grilles within the ceiling of the Charter Hall space. These diffusers/grilles will significantly improve the air distribution within the space also improving the thermal comfort of the Hall's occupants. The ductwork connections to each diffuser/grille shall be provided with a volume control damper (VCD) to allow the appropriate balancing/commissioning of the system. These VCD's shall be positioned so that they are accessible from the proposed new gantry walkway.

Access hatches shall be cut into the new supply air & extract air ductwork to facilitate future maintenance & cleaning of the ductwork again accessible from the proposed new gantry walkway.

All new supply air & extract air ductwork will be fully insulated to mitigate against the risk of condensation forming on the ductwork.

As part of the proposed works, the existing wall mounted controller installed within the Charter Hall space is to be removed & replaced with new. The AHU is to be commissioned & set-up to operate on a simple time clock basis complete with CO_2 monitoring facility. It is the request of the Client that the controls be set to operate as simple as possible and that the Mechanical Contractor fully demonstrates the system to the Client prior to handover.

All new electrical works associated with the new mechanical ventilation system installation are to be undertaken by a suitable qualified Electrical Contractor employed by the Mechanical Contractor.

3.6 ITEMS OF EQUIPMENT TO BE HANDED OVER ON COMPLETION OF THE CONTRACT

a) 'As Built' record drawings in .pdf format plus 2No. full size hard copies.
b) Complete sets of Operating and Maintenance Manuals for all items of equipment supplied in .pdf format plus 2No. hard copies.
c) All relevant testing & commissioning certificates.
d) All warranty information signed and completed by the Contractor where appropriate.

The appointed contractor shall also ensure that sufficient training has been given to the Client to ensure that they are able to use and operate the new system in a simple and efficient manner.

4.0 MECHANICAL STANDARDS & WORKMANSHIP

4.1 AIR HANDLING SYSTEM COMPONENTS

4.1.1 General Requirements

4.1.1.1 Installation

All units shall be correctly accommodated within the areas provided, allowing sufficient space for access, full maintenance and withdrawal of all components.

Permanent lifting facilities shall be made to all individual components of 35kg mass and above to allow removal. Lifting lugs/eyes shall be provided on any unit framework.

Spare drive belts shall be provided, in sets where applicable, for each belt-drive to a total of one complete change per drive.

All components shall be constructed from materials that are not readily ignitable or are suitably flame retardant. Components shall comply with the requirements of BS 9999 for limitation of spread of fire unless otherwise specified in the Fire Strategy.

Materials shall be selected and components arranged to prevent electrolytic action between dissimilar metals.

Where main and standby motors are coupled to a common shaft, drive belts shall be installed on both motors to prevent brinelling of the bearings in the standby motor.

Local isolating switches and external terminal boxes shall be mounted on the item of equipment or immediately adjacent to it.

Filters shall not be fitted until all dust-producing work local to each installation is completed. All openings into plant or ductwork systems shall be fully protected against ingress of dust and debris until final connections are made. Plant, plant areas and ductwork systems shall be cleared of debris and dust immediately before fitting filter cells. Filters shall be installed at times to suit commissioning of the particular plant.

All components shall be 'type-test' certificated in accordance with the appropriate British Standard.

4.1.1.2 Electrical Equipment

Motors with belt drives shall be mounted on slide rails with two adjusting screws. The drive end adjusting screw shall be on the same side as the belt drive and the non-drive end screw shall be on the opposite side.

Isolating switches shall be to BS EN 60947-3 and shall be switch-disconnectors with a minimum utilisation category of AC-23B.

Each individual supply to motors, anti-condensation heaters, heater batteries or other electric components shall be provided with a separate isolating switch. Isolating switches shall have a sufficient number of poles to isolate all live conductors of the circuit simultaneously.

4.1.2 Air Handling Units

4.1.2.1 General Requirements

AHU performance and ratings shall be to BS EN 1886 and BS EN 13053. Certified type test data shall be provided to these standards.

4.1.2.2 Access Sections, Doors & Panels

A lockable access door or panel shall be provided to each AHU section which is not readily accessible by other means. All access openings shall be sized for man access.

Removable panels shall not be more than 1.9m high. Above this height a hinged lockable door shall be provided.

All access doors shall be mounted on hinges and be fitted with door closure furniture. The design air leakage shall be maintained after repeated opening/closing of the doors.

Components shall be withdrawn through access doors or by unbolting panels where necessary.

Panel fixings shall permit repeated removal and refitting.

Access panels shall be secured with a minimum number of proprietary quick-release captive fastenings consistent with effective air sealing. Self-tapping screws and set screws are not acceptable as panel fastening.

Access sections shall provide a minimum access opening of 450mm. The construction of access sections shall be as for the remainder of the unit casing.

An access section shall be provided between any cooling coil and reheat coil to allow for inspection and for an averaging dewpoint temperature sensor to be mounted.

4.1.2.3 Air Leakage

AHU casing air leakage and air filter bypass leakage shall be to BS EN 1886.

All penetrations into AHU frames or panels shall be formed and sealed by the manufacturer.

Airtight sleeves shall be provided for control sensors, instruments and test holes.

4.1.2.4 Arrangement of Components

Even air distribution shall be maintained across the face of all components. The air speed at any point shall not vary by more than ±20% of the mean value.

Drain trays shall have water-sealed traps with outlets extended to the edge of the unit. Drain pipework shall be fabricated in a single length without joints in the run. Trap seals shall be matched to the maximum operating pressure within the relevant section of the unit.

Units shall incorporate corrosion-resistant drain trays to collect and fully drain away condensate, including any condensate from adjacent sections and internal pipework.

4.1.2.5 Controls

Supports shall be provided for mounting serpentine averaging temperature sensors.

4.1.2.6 Corrosion Protection

Sheet steel panels shall be galvanized or have an equal corrosion resistant finish. Mild steel frame sections shall have a minimum two-coat paint finish. Preparation and paint application shall be to the 'Paintwork' section of this specification and the recommendations of the paint manufacturer, to provide a minimum life to first maintenance of 10 years.

All cut edges of metal sheet or sections shall be coated to prevent corrosion.

Units incorporating cooling coils or humidifiers and having any metal surfaces exposed to moisture, shall be protected to provide a minimum life to first maintenance of 10 years. Protection shall extend at least 1m either side of the cooling coil or humidifier.

Units shall have corrosion-resistant drain trays of adequate size to collect waste water, extended to drain away any water deposited or condensed in adjacent sections. Drain trays shall be provided with drain connections and traps. Where the drain tray forms the outer surface of the AHU, the outer surface shall be insulated and vapour sealed.

4.1.2.7 External Units

Units for external installation shall have weather-proof casings and water-tight and water-shedding roofs.

Access doors shall be lockable.

Bulkhead light fittings shall be provided in each section with a weatherproof external switch and all wiring in galvanised mild steel conduit.

External electrical equipment shall be protected to IP 55W minimum. All wiring shall be contained in galvanized conduit.

All joints between casing compartments, access doors and pipework, ductwork and electrical wiring entry points shall be water and vapour-sealed. Penetrations through the casing made for cabling, controls and other ancillary equipment shall be purpose made during manufacture.

Casings and framework shall be thermally insulated to suit the local ambient conditions.

Trim shall be provided around doors and access panels to prevent the ingress of rain and snow.

External finishes shall have a minimum life to first maintenance of 10 years.

4.1.2.8 Fans

Each fan and drive motor shall be mounted on a common frame or other means of support. The complete assembly shall be isolated from the casing to prevent the transmission of vibration.

Electrical connections shall not inhibit free movement of the fan and drive motor set.

4.1.2.9 Flooring

Protection shall be provided to avoid damage to insulation in sections having walk-in access.

Decking suitable for 1.5kN/m2 loading shall be provided within all accessible sections.

4.1.2.10 Jointing

Individual components and sections shall be assembled using proprietary and proven fastening techniques. Locking devices shall be used at all fastenings subject to vibration.

4.1.2.11 Labelling

Each section shall be identified by a clear descriptive label, including component ratings, on the external surface. A warning label shall indicate internal pressure at all points of access.

4.1.2.12 Materials & Construction

AHUs shall be of rigid construction to minimise distortion and drumming in operation. Mechanical strength of casing shall be to BS EN 1886:Class D1, unless otherwise specified.

The casing and frame shall be constructed to withstand the maximum positive or negative pressure created by the associated fans without permanent distortion, when all dampers are shut.

The frame, casings and component parts of units shall be factory assembled and constructed to be sufficiently rigid and robust to withstand delivery, hoisting and movement into position on site without distortion or damage.

Unit frames shall fully support the complete item during installation procedures at site.

All services openings shall be edge coated to prevent corrosion and sealed until the appropriate cable, duct and pipe connections are made.

4.1.2.13 Pipework

Pipework within units shall be properly supported to avoid stress on other equipment items.

The arrangement of pipe connections shall allow individual components to be removed without disturbance to other items of equipment and pipework.

4.1.2.14 Thermal Insulation

The thermal performance of casings shall be to BS EN 1886 Class T1 $U \leq 0.5$ W/m2K, unless otherwise specified.

Thermal bridging of casings shall be to BS EN 1886

Insulation material shall be in sandwich construction for the whole of the external surfaces of the casing. Hollow section frames and posts where used and access doors shall be insulated to the same standard as the casings. Suitable sleeving and weatherproof seals shall be provided at all services, controls and instrumentation items penetrations.

Any surface liable to condensation formation shall be insulated and provided with a vapour barrier. Where free moisture may be present, a waterproof membrane shall be provided.

Drip trays collecting moisture from cooling coils shall be externally insulated. Construction shall be designed to prevent freezing.

Unless otherwise stated in the Fire Strategy, iInsulation materials shall be tested in accordance with BS 476-7 and achieve Class 1 rating or achieve a Class C-s3, d2 rating as defined in BS EN 13501-1.

Mineral fibre material where used shall be resin bonded, and of density not less than 80kg/m³, with provision to prevent settling of the material.

MMMF insulation shall be factory applied and contained within an impervious membrane designed to last the life of the AHU.

Material exposed to the airstream shall be rated non-combustible to BS 476-4 or Class A1 in accordance with BS EN 13501-1, sealed at all edges and joints, and secured to prevent fibre migration into the airstream. Any gaps between support framework, cladding panels and insulation shall be completely sealed between the air path and the insulation.

4.1.2.15 Tests

Air handling units, components and materials shall be tested to the following standards:

- BS 848-2(BS EN ISO 5136).
- BS 5141-1 & -2
- BS 6583.
- BS EN 779.
- BS EN 1886.
- BS EN 13053.
- HVCA DW/144.
- HVCA DW/143.
- HEVAC Guide to air handling unit leakage testing.

Type tests shall include:

- Heating and cooling coils pressure tests.
- AHU casing leakage tests.
- Volumetric tests.
- Thermal capacity tests.
- Motor type tests.
- Noise tests. Full octave band sound power data shall be provided for all AHU connections, and casing break-out, at representative operating points and system conditions.

4.1.2.16 Vapour Barriers

In areas subject to the presence of free moisture or condensation, the insulation surface shall be sealed to prevent moisture penetration and provided with a vapour barrier. All surfaces and joints shall be free of 'cold bridges'.

Vapour barrier water vapour permeance shall be 0.015g/(sMN).

4.1.3 Mixing Section & Dampers

4.1.3.1 General Requirements

Mixing box sections shall consist of a casing housing opposed blade outside air, exhaust air and recirculated air dampers.

4.1.3.2 Performance

Recirculation, exhaust and outside air intake connections shall be sized to suit the maximum design volume flow rate of the air handling unit and the pressure differentials experienced during the full open to closed operation of the dampers used.

External connections shall be flanged with drillings to suit adjoining ductwork flanges.

Air handling unit control and regulating dampers shall match the particular system characteristics and be of dimensions recommended by the component manufacturer. Where the dampers are required to be of smaller dimensions than the unit or duct cross-section, blanking plates shall be provided, securely sealed and fitted to prevent by-pass of air.

4.1.3.3 Damper Sizing

Each damper shall be sized for the maximum required air flow under any operating condition, taking account of the function.

The recirculation damper shall be sized to produce, when fully open, a pressure drop equivalent to the difference between the air pressures in the exhaust and outside air chambers. It shall have a characteristic, not necessarily linear, which complements the outside air damper characteristic to achieve a constant total flow through the fan at all damper positions.

4.1.3.4 Materials & Construction

Dampers shall be arranged for motorized operation.

Blades shall be so formed, and limited in length to prevent twisting, vibration or binding during operation.

Construction shall withstand the maximum positive or negative pressures, created by the associated system fans, without permanent distortion even if all dampers are shut. Air leakage shall not exceed 50 litres/second/m2 of damper area.

The means of motion transmission shall ensure that back lash is minimised and that dampers open and close completely.

Each group of outside air, exhaust air and recirculation air dampers shall have separate actuators.

Each set of damper blades shall interlock when closed. Where two or more damper units are required in order to satisfy this requirement in any one air path, the dampers shall be driven by separate actuators.

Sets of damper blades shall be individually adjustable. Blade positions shall be marked on the spindles. Spindles shall be mounted in bearings.

Blade attachment to spindles shall be a positive mechanical joint. Blades and frames shall be of corrosion-resistant materials to suit application. Materials shall be electrolytically compatible.

Linkage systems shall transmit motion to all connected blades uniformly, such that all blades move an equal amount. The number of driven blades shall be limited to ensure that this requirement is met. Linkage systems shall be designed to eliminate 'slack' movement. Where more than one actuator is used on one damper, the operation shall be synchronized.

4.1.3.5 Actuator & Mountings

Automatic dampers shall be fitted with actuator mounting plates rigidly fixed to the casing to support actuators clear of the airstream.

Actuators shall be of the type in which the damper spindle passes through the actuator and is secured by means of a 'U' clamp.

4.1.4 Air Filtration

4.1.4.1 General Requirements

Particulate filters for general ventilation shall be to BS EN 779. Filters classes shall be selected to suit the application in accordance with BS EN 13779 or as otherwise indicated.

Filter casing air leakage and by pass leakage shall be to the appropriate class in BS EN 1866 for the class of filter housed.

Filter assembles shall be formed of a number of individual filter banks of uniform size. Air flow rate onto filters shall be uniform.

Filter banks shall be retained in a steel or aluminium frame by suitable spring retaining clips which clamp the filter on to its seating equally on all faces. Joints in the frame sections shall be welded or riveted, and individual frames shall be bolted together to form the complete filter bank and to prevent by-pass of air.

Where panel and bag filters are fitted in series the minimum class provided shall be Class G4 for panel filters and F6 for bag filters.

Filter face velocity shall be selected to optimise performance and shall not exceed 2.5m/s.

Each element shall be provided with an effective perimeter gasket to prevent by-pass of air.

Panel and bag filters shall be tested to BS EN 779. Test results shall be provided for each type of filter and include pressure drop dust holding capacity.

Filters shall be fully accessible for inspection, filter replacement and general maintenance.

A manometer indicating differential pressure shall be mounted externally adjacent to each filter assembly.

Filter banks shall be housed in a metal frame. The frame shall not distort in use and shall be treated to prevent corrosion.

Filter banks shall be rigidly and securely held in the frames without distortion with all edges and joints effectively sealed to prevent air leakage.

Filter assembly frames shall be of same supply as the cells.

Gaskets shall be fitted in the holding frames to minimise air leakage around the filters. Gaskets shall allow removal and refitting of filter cells without reducing the effectiveness of the seal. Closed cell foams shall be used.

Filter media and frames shall be constructed of materials that are not readily ignitable or are suitably flame retardant, meet the fire and smoke requirements of BS 9999, BS 476-4 (non-combustibility) and BS 8313 unless otherwise specified in the Fire Strategy.

Plastic components shall be suitable for the conditions in which they operate, including fire and smoke performance.

Panels and bag filters shall be capable of handling at least three times the initial pressure drop without damage.

Air filters shall be labelled in accordance with BS EN 779 and BS EN 13053.

4.1.4.2 Panel Filters

Air filters shall be formed from synthetic (non-fibrous) material.

The final pressure drop at design air flow rate for Class G1-G4 panel filters shall not exceed 150Pa.

Frames shall be manufactured from galvanised steel, stainless steel or aluminium to suit the application. Synthetic filter media shall be supported on a galvanised welded wire grid.

Disposable filters shall have cardboard frames reinforced and treated for use in conditions up to 80% saturation.

Bag Filters

The final pressure drop at design air flow rate for bag filters shall not exceed 200Pa for Class F5 - F7 filters and 300Pa for Class F8 and F9 filters.

Bags filters shall be formed from a matrix of primary and secondary synthetic fibres with a thin layer of high strength spunbond scrim located on the air leaving side to increase filter stability and prevent particle migration. The filter length shall not exceed 750mm.

Bag filters shall have a specific media area of 10m2/m2.

The opening of each pocket/bag shall be bonded to a rigid sub-frame to fit into the filter bank framework.

Bags shall remain fully inflated to expose the maximum filter surface over the full system air flow rate operating range.

4.1.4.3 HEPA Filters

HEPA filtration is a specialist area and application specific. This section should be supplemented by a project specific Particular Specification.

High efficiency particulate air (HEPA) filters shall be to BS EN 1822. HEPA filters shall consist of pleated glass paper or other suitable medium sealed within a rigidly constructed case.

A one-piece, seamless, moulded gasket of suitable material shall be fitted to the downstream face of the filter. Gaskets shall be lubricated to prevent subsequent adhesion with mating face. The lubricant shall be compatible with the gasket and mating face materials.

Test groove seals shall be incorporated.

HEPA filters shall be tested by a UKAS accredited laboratory to BS EN 1822 and BS 3928.

Type test certificates shall be provided for each type of filter.

4.1.4.4 Activated Carbon Filters

Activated carbon filtration is a specialist area and application specific. This section should be supplemented by a project specific Particular Specification

Two-stage filtration shall be provided upstream of activated carbon filters with Class G3 (minimum) primary filters and Class F7 (minimum) secondary filters.

The face velocity and depth of activated carbon filters shall be selected to suit the required dwell time. The minimum dwell time shall be 0.3 seconds and the maximum face velocity 2 m/s,

Activated carbon filters shall have a minimum carbon loading per 40-80 kg per m3/s of air handled to suit the application.

Activated carbon shall be standard grade coconut shell based carbon with a high level of granular hardness. For special applications, impregnated carbon shall be used to suit particular requirements.

The pressure drop of activated carbon filters at design air flow rate shall not exceed 100Pa.

Activated carbon filters shall be capable of operating at up to 50°C and 80% RH.

Activated carbon filters shall comprise beds containing adsorbent medium in granular form evenly dispersed and assembled into a casing sealed effectively against air leakage. Filter medium beds shall be uniformly thick and evenly compacted and shall be of suitable quality and depth to achieve the required concentration in the air leaving the filter.

Each filter assembly shall include two removable sample test sections exposed to the normal air flow to allow the remaining filter life to be tested by the manufacturer.

Final filtration shall be provided downstream of activated carbon filters with Class F6 (minimum) filters.

4.1.5 Air Heating & Cooling Coils

4.1.5.1 General Requirements

Header connections shall terminate 100mm clear minimum of the coil casing with joints to allow complete removal of the coil, arranged such that the coil is removed without dismantling adjacent piping, ductwork, or other equipment. Removal and re-fixing shall be without damage or distortion.

Large coils shall be individual sections each with sub-headers with connections to one pair of common headers.

Headers shall be complete with air cocks and drain valves, to enable full venting, flushing and draining of coils.

Header connections shall be screwed to BS 21/BS EN 10226-1 up to and including 50mm size and flanged to BS EN 1092-3 or BS EN 1092-1 as applicable for 65mm size and above.

Headers and return bends shall normally be contained within the coil casing which shall be airtight for systems operating with static pressure in excess of 750Pa. Where outside the line of the casing, headers and return bends shall be enclosed in removable gasketted airtight covers, close- fitting, profiled to suit the pipe connections, and reinforced to contain a soft sealing split grommet.

Coils shall have horizontal tubes with vertical headers and fins, and be contained within a galvanized mild steel casing.

The casings of duct mounted coils shall be thermally insulated identically to the adjacent ductwork or air handling unit.

Fins shall make full continuous contact with the tubes and extend for the full width and height of the coil casing.

Tubes of multi-row coils shall be staggered in the direction of airflow to maximise heat transfer, be brazed into copper return bends, and terminate in one pair of copper or steel headers for all coil sizes.

Coil design shall provide equal water flow through all coil circuits and arrange water and air in counter-flow.

Side plates and header casings of coil assemblies shall have galvanised steel angle section flanges and supports. Coils shall be mounted on slide rails for ease of removal.

An airtight inspection/access door shall be provided on the 'upstream' side of, and adjacent to, each coil assembly.

The face velocity at cooling coils shall be limited to 2.5m/s where condensation is likely to occur.

Eliminator plates shall be fitted to cooling coils where the face velocity exceeds 2.25 m/s.

Eliminator plates designed to prevent carry-over of water droplets entrained within the air stream shall be of plastic construction and drain naturally into the drip tray. Eliminator sections shall be mounted on rails to allow easy removal and be positioned to avoid damage from heat exchangers located nearby.

Cooling coils and moisture eliminators shall have the drip tray common to both items of equipment, covering the complete area under both units. The inner surface of the drip tray shall be corrosion resistant or treated to prevent corrosion. The outer surfaces shall be insulated to prevent condensation. Plastics drip trays shall be separated from heaters.

Cooling coils exposed to an increased risk of corrosion (e.g. coastal locations) shall be constructed with copper tubes and fins and electro-tinned.

Coatings may be used only as agreed. Polyurethane coating impregnated with metallic pigment shall be used prevent loss of heat conductivity. Coatings shall only be applied by a specialist.

4.1.5.2 Electric Air Heating Coils

Electric heaters shall comprise sheathed elements to BS 7351 mounted on a removable terminal plate for withdrawal for inspection. Terminals shall be housed in a galvanized steel enclosure with hinged access door, conduit entry and electrical termination block. Elements shall traverse the full width and depth of the heater casing. Each element shall be connected to a terminal block in an accessible terminal box with conduit entry.

The surface temperature of the elements shall not exceed 400°C. Each heater shall have a manual-reset thermal cut-out.

An inspection/access door shall be provided on the 'upstream' side of, and adjacent to, each air heater. A hazard warning sign and isolator shall be fitted immediately adjacent to the heater access door, clearly showing operating voltage.

Each heater section shall be separately fused and the neutral point of all 3-phase star-connected sections brought out to a link in the terminal box.

Electrical wiring insulation shall be suitable for the heater maximum temperature.

Each heater shall have a three-contact type manual-reset thermal cut-out to initiate an audible or visual alarm signal on high temperature, with remote sounder/indicator. The cut-out sensor shall be nearest to, and above, the heating elements energised by the first control step.

Heaters shall be interlocked with the system fan motor starters and an airflow sensing device of the vane or pressure type to ensure that the heaters operate only when the fans are running and airflow is established.

The number of elements in the heater shall be the same as, or a multiple of, the number steps in the controller. Heaters, and heater sections of more than 3kW loading each, shall be balanced over 3-phases and the complete heater bank shall be arranged for balanced operation on a 3-phase 4-wire system.

Heater battery output shall be modulated by use of a multi-step or thyristor controller.

The total resistance of the battery to air flow shall not exceed 25 Pa; the face velocity shall not exceed 6m/s and not be less than 2m/s.

Stab-in type duct heaters shall be similar to electric air heater batteries but with the elements supported off a rigid side-plate complete with an insulated terminal cover with conduit entry.

4.1.5.3 Anti-Frost Air Heating Coils

Coils for hot water shall be single or double row with tube wall thickness 0.9mm. Tubes shall be horizontal of plain copper with vertical headers or additionally have vertical fins where necessary to achieve required output.

Where finned coils are necessary, fin spacing shall not be less than 6mm to prevent blocking by fine material. Access and drainage facilities shall be provided for cleaning coils.

4.1.5.4 Chilled Water Air Cooling Coils

The lower part of the coil casing shall be constructed to form a watertight drip tray sloped towards a flush mounted drain connection so that no water is retained in the tray. A chemical glassware drain trap with water seal of sufficient depth, with closable filling leg, shall be provided for drain extension to an open topped gully or tundish.

Where the coil is in excess of 950mm in height, and for multiple blocks, coils shall be arranged with collecting trays to ensure that moisture is carried to a low point and transferred to the lowest tray, without splashing, by means of a downpipe. Draining provisions shall prevent waterlogging.

4.1.5.5 Direct Expansion Air Cooling Coils

Direct expansion air cooling coils design shall be arranged to ensure even distribution of refrigerant to all circuits and prevent the trapping of oil.

Liquid distributor, return suction header and return bends shall be located out of the air- stream. Pipe connections shall be plain end.

Copper tube shall be refrigeration quality to BS EN 12449.

4.1.5.6 Tests

Direct expansion coils shall be pressure tested at works in accordance with BS EN 378-2. On satisfactory completion of all tests the coils shall be dehydrated, charged with a dry inert gas and sealed.

Air coils shall be tested in accordance with BS 5141.

4.1.6 Heat Recovery Devices

4.1.6.1 General Requirements

Heat transfer material or coating shall not support bacteria, fungi or mould growth.

Casings shall have drilled matching flanges for fixing to air handling unit sections or a ductwork system.

Provision shall be made for cleaning the heat exchanger surfaces. Trapped condensate drainage shall be provided.

4.1.6.2 Thermal Wheels

The unit construction shall have a rigid galvanized mild steel casing containing a wheel matrix of corrosion-resistant alloy material treated with a coating with hygroscopic properties to ensure total heat extraction. The foil matrix shall be wound without the use of adhesives but shall be designed to prevent any movement during rotation.

The design and construction of the matrix shall permit degreasing and internal cleaning by use of high pressure steam, water or air.

An adjustable seal shall be provided between the exhaust and inlet airstreams.

The heat exchanger shall be fitted with an adjustable purging sector to prevent the rotor from transferring exhaust air to the supply air duct. The certified carry-over shall be a maximum of 0.05% of the air intake volume.

The drive unit shall be an electric motor with mounting bracket, gear box and drive system with necessary drive guards.

Provision shall be made for adjustment of drive transmission.

Casing and rotor shall be readily removable for maintenance and replacement, with suitable support/lifting and routing arrangements on larger units to meet this requirement.

Access/inspection doors shall be located each side of the regenerator.

4.1.6.3 Air To Air Plate Heat Exchangers

Plate heat exchangers shall be complete with framing and stiffened side panels.

Units shall be of commercially pure aluminium or epoxy coated aluminium. Plates shall be arranged for cross flow of air stream between adjacent passages and ensure no mixing occurs between airstreams.

4.1.6.4 Run Around Coils

The requirements for heating and cooling coils apply.

Run around coils shall be provided with matched pumps, interconnecting pipework, ancillaries and feed and expansion facilities to provide a fully functional system.

4.1.7 Humidifiers

4.1.7.1 General Requirements

Casings enclosing humidifiers shall be air and watertight.

The humidifying equipment shall be complete with all necessary devices for fixing into the required position and be accessible for inspection/removal of all parts.

All materials of construction used shall be suitable for cleaning and sterilising with concentrated chlorine and similar solutions.

The air speed through the humidifier shall not exceed 2.5m/s.

Humidifiers shall be provided with a trapped drain outlet extending from the lowest point of the humidifier casing to the nearest sump or gulley to discharge through an air-break. A water seal of sufficient depth shall be provided to prevent entry or exit of air to or from the system and also maintain a 75mm water seal when the plant is de-energized. The distance between the underside of the humidifier and the crown of its' trap shall ensure the casing can be fully drained.

Electrical heating elements shall incorporate a high temperature cut-out which shall be interlocked with the level control to de-energize the electrical circuit on low water level.

Electrical loads shall be switched in steps and so controlled that the total load cannot be applied in one step.

4.1.7.2 Steam Humidifiers

Arrangements shall ensure that only dry steam is injected into the airstream.

Injection pipes shall be of stainless steel to BS EN 10088-2 grade 1.4435 and BS EN 10095.

4.1.7.3 Self-Generative Steam Humidifiers

Packaged steam humidifiers shall comprise integral cold water supply tank, evaporation chamber, heating elements and controls all mounted on a mild steel framework enclosed in an insulated, mild steel casing.

Units shall be pre-wired internally with terminals for incoming power and control circuit connections. A full height access opening shall incorporate indicator lamps and switches. Output controls shall ensure that capacity is matched to load demand at all times.

Control equipment shall be pre-wired with terminal block, low water level cut-out, controlled pilot heater, indicator lamps, controls fuse and neutral link and provision for humidistat connection all housed in an accessible electrical compartment within the unit casing.

The cold water tank shall be complete with a level control valve, overflow connection, water level gauge and pressure equalizing pipe. The evaporating chamber shall have an inspection cover and outlet flange.

An integral automatic time-controlled flushdown set with copper drain pipework shall be provided.

Self-generative steam humidifiers for direct connection to water supplies shall be WRC approved.

4.1.7.4 Immersion Heater Type

Units evaporating chambers shall contain copper sheathed resistance type heating elements suitable for solid state modulating controls, fixed to a detachable mounting plate.

4.1.7.5 Electrode Boiler Type

Electrode steam boiler humidifiers shall have separate steam and control compartments formed in a mild steel casing. Steam generating cylinders shall contain the heating electrodes and have an outlet hose connecting to the duct steam injection pipe.

Where located within the airstream cylinder construction shall be of non-flammable material. Units shall 'fail-safe' in the event of interruption of power or water supplies. Where cylinders are not re-usable a spare shall be provided with each unit.

Cylinder automatic emptying shall be pump assisted.

4.1.8 Noise Attenuators

Noise attenuators shall be designed, constructed and tested by a specialist manufacturer and match the adjacent assemblies. The airways shall be free from projections into the airstream.

Performance figures including insertion loss shall be derived from tests carried out in accordance with BS EN ISO 7235. Performance shall be achieved under system operating conditions. Attenuator dynamic insertion loss data provided shall include for the use of the vapour barrier.

Attenuator casings shall be constructed from galvanized steel sheet. Joints shall be longitudinal, lockformed and mastic sealed during construction. End flanges shall be welded to the casings, and shall be supplied with slotted bolt holes or other fixing details as necessary.

Casing thickness and flange construction shall be in accordance with DW/144, but with minimum thickness 0.8mm.

Noise absorbent materials used shall be non-combustible, rot-proof and non-hygroscopic. The materials shall withstand an air passage velocity of at least 25m/s without surface erosion or other material migration. Loose or fibrous materials shall be packed under not less than 5% compression to eliminate voids due to settling.

The vapour barrier material shall be resistant to chemicals as required for the application.

Vapour barriers for use in aggressive atmospheres shall not exceed 0.07mm thickness and be installed in a non-taut state. The material shall achieve Class 1 to BS 476-7 or Class C-s3, d2 as defined in BS EN 13501-1.

The direction of airflow shall be clearly marked on the attenuator outer casing.

Rectangular attenuators splitter elements shall be round-nosed and stand vertically and be a close fitting within the casing. L-section and T-section splitter attenuators shall be designed for smooth airflow to minimize self-generated noise. Splitters in bend attenuators shall be fitted perpendicular to the plane of the bend.

Where required, splitter elements shall be easily removable for cleaning. Access panels necessary shall be fitted with effective air-tight seals which shall retain their performance after repeated use.

4.2 FANS

4.2.1 General Requirements

For more infoamtion about fan types, applications and performance characteristics refer to CIBSE TM42 Fan Application Guide.

Fans shall be 'type' tested in accordance with BS 848-1 & -2. Dimensional requirements shall be to BS 848-4, balancing and vibration to BS-848-7 and mechanical safety provisions to BS 848-5.

Sound power level measurements shall be to BS EN ISO 5136 and BS ISO 13347-1 to -4. Fan vibration measurements shall be to BS ISO 14695. Full octave-band sound power levels shall be provided, for the proposed operating points. Where appropriate separate casing break-out sound power figures shall be provided.

Belt-driven fans shall be capable of running continuously at 10% in excess of the selected duty speed and shall have a minimum of two belts.

Fans heavier than 20kg shall be provided with eyebolts or other safe means of lifting.

Provisions shall be made for inspection and removal of internal components including impellers and motors. Casings shall have an access panel incorporating an air seal to facilitate cleaning and maintenance. The inlet and outlet of duct mounted fans shall be flanged to facilitate fixing and removal.

Mounting feet shall be provided where necessary for bolting to a base or supports.

Electrical connections to motors located within fan casings shall be through flexible conduit to an external galvanised mild steel or plastics terminal box secured to the casing in a suitable position.

Anti-vibration mountings shall be provided.

4.2.1.1 Materials & Construction

Fan casings shall be rigidly constructed and stiffened and braced where necessary to prevent drumming and vibration.

Fan casings shall be airtight and manufactured in materials resistant to corrosion from the operating environment. Mild steel components shall be protected against corrosion.

Externally mounted fans and units shall be weatherproof.

All fans shall be statically balanced. Fans shall be statically and dynamically balanced as indicated.

Fan assemblies shall be suitable for continuous operation and all start/stop programmes.

Fan assemblies shall be resiliently mounted to prevent vibration transmission. Centrifugal fan assemblies with indirect drives shall have fan and drive motor fixed to a resiliently mounted common and continuous rigid sub-frame. Due account of operating speeds, static and dynamic loads shall be taken in selection of mounts.

Airtight flexible connections of fire retardant material and of suitable temperature rating shall be made between the fan and adjacent equipment and ductwork. Flexible connections shall be securely clamped in position.

Lubricators shall be extended if necessary to accessible positions.

Rigid protective screens of woven steel wire mesh shall be provided to all unprotected fan inlet and discharge openings.

Airtight inspection doors to motors shall be incorporated.

Bearings shall be suitable for the particular mounting aspect.

Sealed-for-life bearings may be fitted to fans with motors up to 1kW size. Bearings and motor shafts shall be protected against ingress of moisture and dirt.

Where fans are to be suspended on platforms, the fan and motor assembly shall be directly fixed to a common framework attached to the platform by means of vibration isolators. The whole assembly shall prevent significant movement of the fan relative to the ductwork system due to fan torque and thrust.

A fully accessible galvanized mild steel terminal box shall be securely fixed to the outside of the casing of all packaged items of plant.

Casings and bearing and motor supports shall be constructed from mild steel to BS 1449-1.1, Section 1.1 and BS EN 10111.

Shafts shall be of machined bright steel, sized to ensure that the maximum running speed is not more than 60% of the first critical speed determined by the bearing arrangement.

Impellers with shaft power greater than 1kW shall be keyed to the shaft.

4.2.1.2 Motors

Motor characteristics shall be matched to the fan characteristics. Where high starting torque is required to run the fan up to speed in a reasonable time period, a suitable motor shall be provided.

Motors with belt drives shall be mounted on twin slide rails with two adjusting screws. The drive end adjusting screw shall be on the same side as the belt drive, and the non-drive end screw shall be on the opposite side.

4.2.1.3 Belt Drives

Belt drives shall comply with BS 3790 and transmit the rated power output of the motor at any stage of operation with one belt removed. Not less than two belts per drive shall be used.

All multi-belt drives shall use matched sets. Belts shall be of rubber and fibre 'V' section.

Drive pulleys shall be correctly aligned, with belts tensioned to the manufacturer's recommendations. Provisions shall be made for these adjustments. For fans with shaft power up to 5kW, pivoted mounting plates and jacking bolts may be used. For fans with shaft power above 5kW, slide rails and jacking bolts shall be provided.

Where duplicate fan motors driving a common shaft are fitted, the standby motor shall have provision for belt tensioning and shall be ready for operation in all respects. The drive centre to centre dimensions for the common and duplicate pulleys shall be the same. The standby motor shall be belted-up to prevent "brinelling" of bearings.

Pulleys shall be suitable for the belts used. Pulleys may use split taper bushings for drives up to 30kW of an approved type and fitted to the manufacturers' instructions. Alternatively, and for outputs above 30kW, pulleys shall be secured to the fan or motor shafts by keys fitted into machined keyways. Pulleys shall be keyed to the shaft in the overhung position. Keys shall be easily accessible for fixing and withdrawal and not protrude beyond the end of the shaft. Provision shall be made to remove all pulleys from shafts.

Guards shall be to BS PD 5304 and be provided to all forms of open power transmission systems.

Removable guards shall fully enclose indirect drive systems to prevent accidental contact with dangerous parts of machinery. Guards and access panels shall not be removable without the use of a tool.

Guards shall be rigidly constructed from metal mesh or plate fixed to a framework. The mesh size and arrangement of the guard shall prevent finger penetration.

The sizes of guards including the dimensions and locations of access covers shall provide for the extreme motor position.

For duplicate motor installations, the guard shall be arranged to protect both drives. Provisions shall be made to permit changeover of the drive.

Extended fan shafts shall be protected with a galvanized steel mesh or sheet metal guard shaped to suit the components and be removable for maintenance. Guard construction shall be as for belt drives.

Axial Flow Fans

Axial flow fan casings shall be of rigid construction, of mild steel treated against corrosion, or of aluminium alloy, stiffened and braced where necessary to minimise drumming and vibration.

Casings shall be flanged at each end. For in-duct mounting, the length of the fan casing shall be greater than the combined length of the impellers and motors. For open inlet application, a guarded bell-mouth inlet shall be fitted.

Axial fan impellers shall be hot dipped galvanized mild steel, aluminium or moulded reinforced plastics.

Impeller blades shall be of aerofoil section.

Fans shall be provided with attachable mounting feet and anti-vibration mounts where necessary.

4.2.2 Bifurcated Fans

Casings shall be of the same thickness throughout and shall extend for the overall length of the impeller, hub, and motor protection tunnel as applicable, and have circular flanged ends. Casings shall be mild steel with continuously welded joints.

The impeller shaft shall have a seal at the tunnel wall to prevent air or gas leakage in either direction between the motor tunnel and the fan airways.

4.2.3 Variable Pitch Fans

Variable-pitch fan blade mechanisms and control actuators shall be supplied by the fan manufacturer.

The pitch of all blades shall be varied simultaneously and the difference in pitch between any two blades throughout the operating range shall not be greater than 0.5 degrees. The total backlash between actuator and blades shall not exceed 0.5 degrees.

The variable pitch mechanism actuator shall provide fully modulated control of the fan air volume to match the system characteristic.

Spring return actuators used for fan blade control/variable air volume fan control shall turn blades to maximum or minimum pitch on control power failure.

Forces due to control actuators mounted inside the hub shall be contained within the hub and not transmitted to the drive shaft. Forces due to control actuators mounted outside the hub shall be applied on the axis of rotation of the hub.

Ball or tapered roller thrust bearings shall be used throughout.

The actuator, if mounted outside the impeller hub, the fan impeller, and the actuating linkage shall be arranged to prevent interaction between impeller and actuator due to changes in aerodynamic forces caused by changes in blade pitch.

Pneumatic actuators shall use pilot or positive positioner relays which cause the actuator to modulate on any change in controller output pressure greater than 4% of the range of pressures used to obtain the specified fan values. Actuators without pilot or positive positioners shall have sufficient gross thrust to achieve the same effect.

At least 90% of the actuator's possible travel shall be used to achieve the required change in pitch angle. Any excess movement available shall not reverse the airflow or overload the fan motor.

The variable pitch mechanism shall cause a change in system air volume which is proportional to the changes in position of the actuator spindle over the operating range required.

The change in pitch angle shall be proportional to the actuator spindle movement between the maximum and 40% of the maximum specified volume.

4.2.4 Centrifugal Fans

Fan scrolls shall be mild steel with welded joints and welded angle stiffeners. For fans with a static pressure not exceeding 1kPa the scroll may be formed of mild steel with lock-formed joints and spot-welded scroll supports and bases.

For fans less than 800mm diameter and of speeds below 20Hz, casing stiffeners may be the folded edges of welded side plates used to form the pedestal and scroll.

Arrangements of fan scrolls shall allow removal of the impeller.

Inlet and discharge connections shall be flanged, with an airtight joint between the scroll and flange. Where the difference in static pressure between the fan inlet and surroundings is less than 500Pa the inlet connection may be a plain circular spigot.

Scrolls, where painted, shall be properly prepared, prime coated and finished with a fully protective scheme to prevent corrosion and deterioration.

Multi-vane impellers for centrifugal fans shall be constructed from mild steel to BS 1449-1.1, Section 1.1 and BS EN 10111.

Impellers may be fixed to shafts with machine or grub screws for shaft powers less than 750W provided that the screws bear onto machined flats on the shaft.

Forward curved impellers for shaft powers below 1kW may be of stamped formed strip, if the fan efficiency and required impeller balance grade to BS ISO 1940-1 and BS ISO 11342 can be achieved. For shaft powers above 1kW, impeller blades shall be single thickness mild steel, riveted or welded to the cage. Braces shall be bolted, riveted or welded to the cage and hub. Stressed wire or screwed stud bracing shall not be used.

Backward curved impeller blades shall be of mild steel, have true aerofoil performance and be riveted or welded to the cage except for shaft powers below 1kW, where the impeller may be die-cast aluminium alloy or similar, if the fan efficiency and required impeller balance grade can be achieved.

Double-inlet double-width fans shall have two identical impellers mounted back-to-back on a common shaft.

Impeller bearings shall be ball or roller type and shall be self-aligning. Plummer blocks, or similar split bearing housings, shall be used on fans with shaft powers greater than 10kW. Bearings shall be replaceable on belt-driven fans of input shaft power 5kW and above.

Fans with overhung impellers shall have two bearings mounted on a pedestal to which the fan casing is also rigidly attached. Fans with bearings on both sides of the impeller shall have bearer bars attached to the framework of the scroll stiffening and base. Bearings and bearer bars shall be designed to withstand any end thrust due to aerodynamic forces on the impellers.

Rubber-bushed bearing mountings shall not be used on belt driven fans.

Lubrication points shall be self-sealing or have captive dust caps. Oil reservoirs shall be located in positions at the same static pressure as the bearing served.

4.2.5 Mixed Flow Fans

Fans and motors shall generally comply with requirements and materials for axial and in-line fans.

Automatically controlled inlet guide vanes and outlet stator vanes shall be fitted.

4.2.6 Plug Fans

Note that plug fans are much less efficient that backward curved centrifugal fans.

Plug fans shall be mounted in an air handling unit providing suitable protection.

Impellers shall have backward curved blades. Impellers shall be of welded sheet steel construction. Impellers shall be dynamically balanced at maximum speed to ISO 1940 grade G6.3 and grade G2.5 for larger sizes.

Inlet cones shall be formed in one piece and fitted to the end panel. The inlet cone and end panel shall be manufactured from galvanized sheet steel. Inlet cones shall be specifically designed to maximise fan efficiency and minimise noise.

Plug fans shall have an epoxy powder paint finish.

Plug fans shall be fitted with an integral differential pressure sensor and transmitter to accurately measure air flow. The transmitter shall have 0-10V outputs.

Plug fans shall have an integral direct drive variable speed motor. An integral frequency converter shall provide motor management and protection functions and shall include an EMC filter complying with EN 61800-3 (Environmental Class 1, restricted distribution).

Plug fans shall have a protective screen fitted on the inlet.

Fan performance shall be tested in accordance with ISO 5801 and 13347-2.

4.2.7 Propeller Fans

Propeller fans shall be ring or diaphragm mounted. Impellers shall be of steel, aluminium or plastics with blades securely fixed to the hub, or the hub and blades may be formed in one piece.

4.2.8 Packaged Duplicate Extract Fan Units

The housings of packaged units shall contain all components of the unit. The housing shall be provided with dust-protected access covers to IP 51 to allow inspection and replacement of all components. No electrical component shall be fixed to or supported by any access cover. All items shall have a non-corroding finish.

Housings and cowls of externally mounted units shall be weatherproof, manufactured from galvanized mild steel or aluminium alloy sheets or glass reinforced plastics to BS 3532, assembled with compatible and non-corroding nuts, bolts, washers and ancillary items.

Discharge outlets shall be weatherproof with guard screens to IP 20, BS EN 60529.

Each fan damper shall close when the fan is de-energised.

Duplicate fans and motors shall be fitted on a common baseplate supported on anti-vibration mountings.

Backdraught dampers shall have edge seals.

Fan failure in units of less than 500W fan shaft power may be sensed and indicated from switches operated by damper blade movement. Double throw airflow switches shall be used in units of 500W shaft power and above.

4.2.9 Roof Extract Units

Cowls and bases shall be of materials resistant to adverse weather and solar radiation, and appropriate for the location of the fan. Casings shall be weather proof, and shall be suitable for direct fixing to the building in accordance with the manufacturer's instructions. Backdraught dampers and auxiliary components shall be fitted.

Direct access to electrical supply terminals and lubrication points shall be provided.

4.2.10 Small In-Line Centrifugal Fans

Fan casings shall be rigidly constructed of mild steel protected against corrosion, aluminium alloy, or glass-filled polymer and shall be stiffened and braced where necessary to minimise drumming and vibration. Mounting feet shall be provided as necessary. Each inlet and outlet shall terminate in a flange to BS ISO 6580 to permit removal. Stator vanes shall be of mild steel or aluminium alloy.

Provision shall be made for inspection of fan impeller and motor.

Fans connected at both ends to ducted systems shall have circular cross section casings which cover the overall length of the impeller, impeller hub, motor and any ancillary fittings.

Impellers shall be mild steel, aluminium or glass-filled polymer with blades firmly attached to impeller hub and shroud. Impellers with outside diameter 500mm or less may be die-cast aluminium with a fitted shroud.

Fans with externally mounted motors shall have twin ball or roller bearing mounted steel impeller shafts. Drive arrangements shall minimise air leakage and allow access to pulleys and belts.

4.2.11 Smoke Ventilation Fans

Fans to be used for smoke extract ventilation shall be of all steel construction with fire rated flexible connections and be to BS EN 12101-3-2.

Motors, electrical cabling and components shall be suitable for the application and rated to ensure fans pass the required "hot gas volume" of air at NTP.

Impeller and casing clearances shall be satisfactory at the operating temperatures.

Units shall be type tested to the standards of the Smoke Ventilation Association, or FIRTO witnessed-tested to the temperature/time criteria applicable.

4.2.12 Cowls for Roof Mounted Fans

Cowls shall be manufactured from pressed steel sheet galvanized after manufacture, die-cast or spun aluminium, or moulded glass reinforced plastic to BS 3532. Cowls shall be assembled with accessories of compatible and non-corroding materials and shall be resistant to contaminants to be handled.

Roof mounted intake cowls shall have inlets which face directly at the roof surface or have a continuous inlet around the perimeter which faces the roof at an angle not exceeding 45 degrees.

The exterior shape and the mounting and fixing arrangements of cowls shall be suitable for the roof structure on which they are installed.

Cowls shall be suitable for kerb mounting with a total height above roof level not less than 150mm. The fixing may be to the kerb or roof structure.

Kerb-mounted cowls shall have a skirt to weather-protect the junctions between the cowl and the kerb seating. The skirt shall not be the fixing member.

Purlin-mounted cowls shall have a skirt suitable for weathering the overlap of a soaker sheet upstand and the cowl throat. Cowls shall be fixed to purlins, or purlin trimmers, and the weight of the cowl shall be distributed over the upper surface of the purlins or trimmers, by flanged inlets to the cowl "throats". The throat length shall be suitable for the depth of roof structure including a minimum 75mm clearance between the skirt and any part of the roof surface.

Soaker sheets shall match the form and colour of the roof surface. Soaker sheets shall have an end lap not less than 150mm, and side laps equivalent to 1½ corrugations or the corresponding standard laps for the roofing surface which the cowl penetrates.

The loss of total pressure through the cowl, including the discharge velocity pressure and any losses due accessories shall be added to the system resistance in the determination of the fan duty.

Cowls discharging humid or contaminated air from ducted systems shall be constructed so that an airtight joint can be made between the throat of the cowl and the duct. The throat and the discharge space under the weathering cap shall be separated from any internal voids in the cowl and the space between the weathering skirt and throat.

Backdraught dampers on vertical discharge cowls shall be protected from cross-winds by an external weathershield. The height of the weathershield shall be a minimum of 25mm greater than the open height of the dampers. The dampers shall be weatherproof when closed. Blade hinges shall be positioned outside the perimeter of the discharge air jets, or shall be positioned directly over a channel which drains to the outside of the cowl. The damper blades shall oversail their seatings and have lipped edges.

Bird guards of 12 - 15mm square mesh shall be fitted to all intake cowls.

4.3 DISTRIBUTION SYSTEMS - DUCTED

4.3.1 General Requirements

Materials, construction and identification shall be to B&ES DW/144 and the requirements of this Specification.

An alternative to testing all ductwork is to meet the Building Regulations e.g. including all systems where: fans with a design flow rate of 1m3/s or more; the pressure class is such that DW/143 recommends testing; BER calculations assume a lower leakage rate than DW/144 (when low pressure systems shall be tested at medium pressure); or to specific requirements given on the Equipment Data Sheets.

All shall be leakage tested to B&ES DW 143 including all parts of high pressure, medium pressure and low pressure systems unless otherwise specified.

Ductwork leakage testing shall be carried out in accordance with the Building Regulations including PartL.

Ductwork leakage testing shall be to B&ES DW/143.

Ductwork must be tested by a suitably qualified specialist contractor.

If a ductwork system fails to meet the required leakage standard, remedial work shall be carried out as necessary to achieve satisfactory performance in re-tests and further ductwork sections shall be tested as set out in DW/143.

All necessary ductwork, control, isolating, fire, smoke and balancing dampers, grilles and diffusers to form complete air distribution systems shall be provided.

Plastic ductwork if specified should comply with DW154. This shall be limited to specified locations only.

Sheet metal for fabrication shall be new, smooth and free from blisters, pits and imperfections in coating. Galvanising shall be to BS EN ISO 1461. Raw edges and areas of metal where galvanizing has been destroyed shall be cleaned, prepared and painted with zinc-rich paint to BS 4652 at works. Transit damage shall be repaired at site prior to erection. All cut edges shall be repaired with zinc-rich paint to BS 4652.

Ductwork installations shall be rigid, free from sway, drumming and movement. Ductwork shall be true-to-size and accurately aligned.

Connections to associated equipment and other fittings must also be in proper alignment, to prevent turbulence and associated noise and vibration.

As far as practicable, longitudinal seams shall be aligned where permanently visible after installation.

Duct sizes are clear internal required airway dimensions. Allowance shall be made for any acoustic linings and their coverings. There shall be no obstructions or rough surfaces within any ductwork.

Cross-breaking and beading shall not be permitted on ductwork where rigid external insulation is to be applied.

Take-offs shall be factory-made conical, bellmouth, or shoe type. Duct size square take-offs from main ducts shall not be used.

Holes in main ducts for branches shall not be greater than the branch size.

Perforated rivets shall not be used in manufacture or erection of ductwork. The use of self-tapping screws shall be restricted to the completion of site joints in extremely difficult locations only where alternative methods are not possible. A record of these locations shall be submitted.

Duct branches and equipment items shall be supported locally to prevent distortion.

Instrument and controls penetrations and connections shall have adequate local stiffening to provide rigid mountings.

Where internal linings are required, fixings shall ensure that the lining is held in continuous contact with duct surfaces under all operating conditions to prevent detachment and fibre migration.

Flexible connections shall be made between ductwork and fans and other equipment items.

Access shall be maintained to ductwork system components which require inspection, cleaning, or adjustment.

At every point of duct penetration of the building envelope, a sealed louvre, weather cowl or protective flashing and full closure plate shall be provided to prevent ingress of water.

Ductwork and plenum immediately behind an intake or exhaust louvre shall be painted on all internal and external surfaces for a distance from the louvre equal to the louvre height or to the nearest equipment item, whichever is the lesser. The paint is to be selected for wet/dry alternating conditions (epoxy resin or bitumastic paint) and shall have a minimum life to first maintenance of 10 years. The bottom side of the ductwork connection shall have a 15° minimum slope towards the louvre and arranged to drain out through the louvre.

Fume or vapour-laden ducts shall be sloped down to a drainage point. Where ducts are metal, there shall be no cross-breaking to the bottom panel on the inside.

All metal fasteners shall be entirely compatible with the materials used.

Where site dimensions cannot be obtained in advance of preparation of fabrication drawings, provision shall be made to accommodate any discrepancies between the drawings and site requirements. The fabrication drawings shall show provisions for dismantling by means of bolted, gasketted flanged joints.

4.3.2 Ductwork Cleanliness

A Medium cleanliness quality class as defined in TR/19 shall be achieved for all ventilation systems unless otherwise specified. Testing shall be carried out on all systems to demonstrate that the acceptable dust accumulation levels are achieved.

Ductwork protection, delivery and installation shall meet TR/19 Intermediate PDI unless otherwise specified.

Provisions made for access for cleaning shall be generally to TR/19. Specialist cleaning contractor shall confirm whether additional provisions are required.

Ductwork shall be cleaned without detrimental effect to finished areas.

4.3.3 Ductwork Construction

Sheet metal for ductwork, to be galvanized to BS EN ISO 1461 after manufacture, shall have minimum thickness as described in DW144 unless specified higher in equipment data sheets.

Flat oval ducts shall be of spirally wound construction.

Stiffening provisions shall be incorporated.

Flanged joints shall be located at all plant and equipment items, at structural walls and floor slabs and elsewhere where required for disconnection purposes.

Splitters shall be fitted in short radius bends over 300mm deep and in all change-direction fittings, except in kitchen exhaust ventilation systems.

Circular radius pressed bends shall have one diameter throat radius.

Tapers for circular ducts shall not exceed 22.5 degree.

Sheet metal casings to air handling equipment components shall be jointed to suit the maximum operating pressure and permitted air leakage.

Self-adhesive tapes shall not be used. Glass fibre reinforced tape only shall be used and shall be fixed with spray-applied adhesive at site. The use of tape shall be restricted to the completion of site joints in extremely difficult locations only where alternative methods are not possible. A record of these locations shall be submitted.

Ductwork connections to building openings, external louvres, grilles etc. shall have compatible flanges for airtight fixing.

Kitchen ventilation ductwork shall be to DW/144, DW/172 and there shall be no longitudinal seams on the underside of extract ductwork.

4.3.4 Hangers & Supports

Supports for internal ductwork shall generally comply with DW 144, except that attachment of horizontal ductwork from duct flanges or stiffeners shall not be permitted unless specified.

All ductwork shall be securely held and aligned.

Support spacing and loads shall include all ductwork system components which cannot be provided with individual supports such as acoustic insulation or fire cladding and balancing dampers.

The size strength and materials used for external ductwork supports shall be suitable for the ductwork, system components, insulation, cladding and prevailing external conditions. Cross bracing shall be provided between adjacent supports where necessary to resist wind loading.

Full details of all hangers and supports shall be submitted.

Supports shall be external to insulation.

Wire rope suspension systems shall not be used unless specified.

Fixings particularly specified for supports shall not be varied.

Duct hangers wherever exposed in humid air or to view shall be protected by a suitable paint scheme or hot dip galvanizing after manufacture.

Horizontal ducts shall be supported at spacings in accordance with DW144, and additionally at branches and equipment items. Vertical ducts shall be supported off floor slabs and by purpose-made brackets fixed to the structure where spacing exceeds 4m.

Hangers for ducts to be thermally insulated shall provide clearance for the insulation and any vapour barrier or other covering to be applied and finished. Horizontal bearers shall be lined with low compression insulating material.

Where personnel entry into the duct is necessary, floor plates connected to stiffeners shall be provided to accept the loading, with suitable additional local supports.

4.3.5 Access Openings

Access openings shall be located, arranged and sized to permit full access required for maintenance. Inspection covers shall permit associated equipment item to be viewed.

Access for inspection and cleaning shall be to TR/19 and DW144 unless otherwise specified by the ductwork commissioning contractor and specialist cleaning contractor. Inspection panels shall also be provided at:

Other items of equipment (e.g. humidifiers).

Turning vanes.

Base of risers.

Access openings and inspection covers shall be rigidly framed, with gasketted airtight covers designed for easy removal and accurate relocation and fixing.

The minimum number of quick-release fastening devices compatible with the loading shall be used.

Self-tapping screws shall not be used.

Access to fire and smoke dampers shall permit quick and easy manual resetting of the shutter.

Access covers shall have retention devices.

Personnel access doors shall be hinged, a minimum of 600mm wide and 1800mm high, or the duct depth whichever is smaller, and fitted with restrainers.

Hinged access doors with double-sided operating handles shall be provided as required.

Proprietary insulated double-skin hinged access doors shall be fitted in all insulated ducts.

In addition to an access opening, a tundish with trapped drain outlet size DN 40 (minimum) shall be provided at the base of kitchen extract ventilation risers.

4.3.6 Test Holes

Test holes shall be provided in all main and branch ducts and adjacent to all duct-mounted temperature and humidity sensors.

Test holes shall be 15mm diameter for plain ducts and 25mm diameter for insulated ducts, closed with soft sealing plugs. Test holes shall not impair the rigidity of the ductwork.

Locations of all test holes for balancing, commissioning and sensors testing shall be agreed, and subsequently marked and recorded.

Test holes shall be accessible for airflow measurement, system balancing, testing and commissioning.

Balancing and Control Dampers

Dampers shall be constructed to DW/144.

Non-return (self-closing) dampers shall be constructed to ensure positive shut-off and quiet closure.

Single-blade dampers shall have a maximum duct width of 300 mm and a maximum duct height of 300 mm for rectangular ducts; and for circular ducts a maximum diameter of 315 mm.

Dampers shall be installed in permanently accessible positions.

Balancing dampers shall be fitted in each branch from a main or sub-main duct, and elsewhere as required to satisfactorily commission the system. The required distance from the branch-piece shall be maintained.

Automatic damper actuators shall have:

Sufficient torque to open and close against the maximum out-of-balance pressure across the damper.

Position indicators, unless fitted to terminal units.

Manual override facility, unless fitted to terminal units.

A linear stroke/control signal characteristic.

Full octave-band sound power data shall be provided for representative damper settings, flows and associated pressure drops.

4.3.7 Fire & Fire/Smoke Dampers

Requirements for smoke dampers may differ from fire/smoke dampers.

Fire dampers and fire/smoke dampers shall be provided as described in BS 9999 unless otherwise specified in the Fire Strategy.

Fire dampers and fire/smoke dampers shall be classified to BS EN 13501-3 and tested to BS EN 1366-2.

Fire dampers and fire/smoke dampers shall have an integrity E rating at least equal to the fire resisting wall or floor in which they are installed and not less than 60 minutes (E60).

The manufacturer's instructions must be strictly complied with regards to fixing and installation and reflect the tested and certified installation details.

Fire dampers of the cased folding-blade spring-loaded type shall have a replaceable and re-settable release mechanism. In the open position the blades shall not restrict the airstream. Dampers for horizontal mounting shall have stainless steel closure springs and positive blade locking devices. Dampers in circular or flat oval ductwork shall have integral spigots to suit the containing ductwork.

Plate (single) blade type fire dampers shall be arranged to close against full perimeter stops following blade release by a temperature-sensitive device. The casing shall be of appropriate thickness for the fire rating. Means of blade and release device reset shall be provided.

Motorised fire and smoke dampers must be fitted such that the motor and control elements can be accessed for maintenance/replacement in accordance with the Manufacturer's requirements. All controls and power cables must be appropriately fire rated for the use and must be connected to the life safety power supply for the building.

Damper assemblies shall be of corrosion-resistant materials or have protection against corrosion which shall not impair their operation.

In line with manufacturer's installation instructions and details, purpose-made installation frames with expansion allowance shall be provided and be built into formed openings in fire compartment walls, floors or other openings designated. The joint line shall be masked with firmly fixed metal plating all round to prevent penetration of any gap by flames or gases.

Openings sizes shall be restricted to require minimum certified fire stopping material, to provide a homogeneous construction and maintain the fire resistance of the penetrated element.

Fire dampers and frames shall be adequately supported and shall not be supported by adjacent ductwork.

Fire dampers and frames shall always be set parallel to the plane of the wall or floor.

Where dampers cannot be positioned in the thickness of a fire barrier, ductwork or casing between the barrier and the furthest side of the damper case shall be enclosed with fire resistant material of equal fire rating to that of the fire barrier. The damper, casing and applied protection must be adequately supported and fixed to the barrier, in accordance with the manufacturers recommendations. This installation method must be confirmed by the manufacturer as being within the bounds of their certified installation details.

Dampers for flexible cavity barriers shall be fixed as the manufacturers' recommendations for the application. Suitable frames and brackets shall ensure compliance with fire test methods.

Blade release mechanisms normally retaining fire dampers in the open position shall operate at 72°C ±4°C.

Smoke detectors and fire/smoke damper automatic release mechanisms shall be to BS EN 54-7 and BS 5839-3 respectively.

Access doors shall be provided adjacent to fire and smoke dampers for inspection and be of sufficient size to permit resetting of release mechanism and blades by one person.

Access to fire damper and smoke damper assemblies shall also be provided through building fabric and builders work elements. Any access provision shall not compromise the fire rating of the elements in which they are provided.

It should be ensured that the installed dampers are working correctly in line with the requirements of the approved Fire Strategy and the associated cause and effect.

The relevant manufacturers data and certification must be provided to the client at Practical Completion as part of the O&M manuals.

4.3.8 Fire-Resisting Ductwork

All fire-resisting ductwork shall have a valid fire test or assessment certificate.

Fire-resisting ductwork shall achieve the requirements of protection Method 3 described in BS 9999 and be certified in accordance with BS EN 1366 Parts 1, 5, 8 and 9 as relevant to the specific installation.

The fire resistance of the ductwork, when tested from either side, shall not be less than the fire resistance of the construction elements in the area through which it passes.

The ductwork shall be constructed to meet the requirements of stability, insulation and integrity unless specifically otherwise defined in the Fire Strategy. Fire-resisting ductwork shall be insulated where necessary to achieve these requirements. Insulation to be used must be included in the manufacturers test or assessment documentation. Alternatives are not acceptable.

Ductwork identified as providing smoke extract must maintain a minimum cross sectional area of 90% in accordance with BS EN 1366-8.

The ductwork support system shall also satisfy the requirements of BS EN 1366-1. There shall be written evidence of the certificates of conformity and the fire test reports; these shall be provided when the product is proposed. This data shall include the evaluated level of fire performance and the scope of application.

Unless the Manufacturer can provide an appropriate assessment for an extended field of application then unprotected suspension devices must not be longer than 1.5m without insulation protection to ensure that a maximum permissible extension of 40mm is not exceeded as per Section 13.6.2 of BS EN 1366-1.

Access panels shall be provided for components as described for ductwork. Panels shall be suitable for frequent use without compromising the fire rating and leakage performance of the ductwork.

- Testing of smoke extract ducts to BS EN 1366-8 requires evidence of compliance with the following additional failure criteria:
- Reduction in cross section: The internal dimensions of the duct must not decrease by more than 10% during the test.

Stability: The duct inside the furnace must maintain its smoke extraction and fire resistance function without collapsing.

The relevant manufacturers data and certification must be provided to the client at Practical Completion as part of the O&M manuals.

4.3.9 Flexible Connections

Flexible joint connections shall be tightly formed to prevent air leakage. The material shall remain flexible and without strain or distortion.

Flexible joints shall be 50mm minimum and 250mm maximum lengths and shall not intrude into the airway under any condition. Ductwork shall be supported and aligned to prevent undue stress in the flexible joint.

Flexible joints shall be fire rated and tested in accordance with BS 476-20 or BS EN 1366-1.

Flexible connections shall be to BS 9999 unless otherwise specified in the Fire Strategy.

4.3.10 Bendable & Flexible Ducts

Non-rigid ducts shall be of bendable aluminium, flexible metal or flexible fabric construction.

The maximum length of each non-rigid section shall be 600mm.

Changes in direction shall be formed in long radius. Bends where necessary shall be two per length with 90° minimum included angle. Minimum throat radius shall be one diameter.

Adequate support shall be provided to prevent sagging. Kinked or flattened non-rigid ductwork will be rejected.

Test holes required shall be formed in rigid ductwork adjacent to flexible sections.

Ducting shall comply with air-tightness requirements for rigid ducts in the same system.

Where required, ducts shall be insulated with soft-formed insulant with external finish.

Reinforcement of flexible fabric ducts shall be carried over air terminal and rigid duct branch spigots and secured with clips and sealant as recommended by the manufacturer. Plastic tie-wraps shall not be used.

4.3.11 Low Velocity Plastics Ductwork

Plastics ductwork and fittings construction and installation shall be to DW/154.

4.3.12 Sound Absorbent Duct Linings

Lining materials shall be fixed to internal surfaces of airways in locations and of thicknesses specified, to leave the indicated clear airway dimensions after application. All joints and cut edges shall be sealed to prevent erosion, and to present a smooth face to the airstream.

Adhesives shall be flame retardant after application and achieve Class A1 in accordance with BS EN 13501-1unless otherwise specified in the Fire Strategy.

Lining materials used shall be rot-proof, on-hygroscopic and achieve Class A1 in accordance with BS EN 13501-1 unless otherwise specified in the Fire Strategy.

The complete assembly of materials shall be non-combustible as defined in BS 476-4 or achieve Class A1 in accordance with BS EN 13501-1 unless otherwise specified in the Fire Strategy.

Damaged factory linings will be rejected at any stage of delivery, storage or erection of systems.

The installed duct lining shall have the following minimum sound Absorption coefficients when measured in accordance with BS EN ISO 354.

Thickness (mm)	Octave Band Centre Frequency (Hz)					
	125	250	500	1k	2k	4k
15	0.1	0.25	0.45	0.65	0.9	0.85
25	0.1	0.35	0.55	0.85	0.95	0.95
50	0.35	0.5	0.85	0.95	0.95	0.95

4.3.13 Thermal Insulation

Provisions shall be made for the fixing of thermal insulation material.

4.3.14 Identification of Ductwork

Ductwork shall be identified in accordance with the recommendations of DW 144 for the purposes of commissioning, operation and maintenance of the systems.

The type of air being conveyed, the direction of flow, the destination of the air and/or the location or nomenclature of the plant where the air was treated shall be provided by the ducts identification.

The identification must be placed where it can be easily seen and at positions where identification will be required, taking the following into consideration:

The symbols should be on the surfaces which face the positions of normal access to the completed installation.

The symbols should not be hidden from view by structural members, other ducts, plant, or other services distribution systems.

The symbols should be placed, where possible, where there is adequate natural or artificial light.

The colour coding indicating the type of air being conveyed shall follow the table below.

Type	Colour	BS 4800
1	2	3
Conditioned air	Red and Blue	04 E 53 18 E 53
Warm air	Yellow	10 E 53
Fresh air	Green	14 E 53
Exhaust / extract / recirculated air	Grey	00 A 09
Foul air	Brown	06 C 39
Dual duct system – hot supply	Red	04 E 53

Dual duct system – cold supply	Blue	18 E 53

For conditioned air, two symbols (one red, one blue) may be used, or a single symbol coloured part red, part blue.

To indicate the direction of the air flow an equilateral triangle with one apex pointing in the direction of air flow shall be used. Where the boundaries of the duct are not visible, two triangles should be arranged in line ahead to indicate direction of flow.

The size of the symbol will depend on the size of the duct and the viewing distance. The symbol shall have a minimum size of 150 mm length of side.

Further information to be given shall include the space served by the duct and the associated plant. The information should be given as briefly as possible using commonly accepted forms.

Where identification of the space is by room number, this must be agreed with the user.

The letters and numbers should be in either black or white, whichever gives the better contrast. They should be marked on the colour symbol or immediately adjacent to it. The size of the figures will depend on how easily they can be seen, but should not be less than 25 mm high.

Explanatory charts and damper schedules shall be provided and copies displayed in each plantroom. The chart should show and explain the colour symbols used on the installation and where appropriate the figure and letter codes used for further identification.

Symbols shall be permanently affixed to ducts by use of painted, stencilled letters and figures or self-adhesive plastics applied to a smooth clean surface, or by use of engraved plastic or metal labels riveted to equipment items.

Symbols shall be set at 6m intervals on main ducts and within 3m of the main on each branch as a minimum. Symbols shall be fitted in positions to be easily read from operators' level.

Special ductwork shall be identified by particular alphanumeric or colour codes.

Fire-resisting ductwork additionally shall have the words "FIRE DUCT" permanently marked in red at 4m intervals with letters 50mm -0/ + 5mm in height.

4.4 AIR HANDLING ANCILLARIES

4.4.1 Air Grilles & Diffusers

4.4.1.1 General Requirements

Air grille and diffuser components shall be truly cut and accurately assembled. Exposed welding shall be neat and ground smooth.

Finishes adjacent to air grilles and diffusers fixed in their final positions shall be unmarked.

Air grilles and diffusers shall be square to structural lines, flush with surfaces and level and lineable with adjacent items.

Blades and all surface fixings shall have finish to match the finish of any grille or diffuser border. All control mechanisms and visible internal parts shall be matt black finish.

Poorly finished or poorly fitting air grilles and diffusers will not be accepted.

Samples shall be provided for all types of air grille and diffuser and assembly to establish the standard of finish and fit required. All samples shall be retained at site.

All fittings and sub-frames associated with grilles and diffusers shall be securely fixed to the surface in which they are mounted.

Core elements shall be readily removed from sub-frames.

Sill-mounted grilles may be press-in spring clip fit into a sub-frame, or other permanent retaining opening.

Plenum boxes shall be supported directly from the building structure and in accordance with the air diffuser manufacturer's recommendations.

Plenum boxes shall be acoustically internally lined unless otherwise specified.

Full octave band sound power data shall be provided at representative airflow rates and where appropriate damper settings. Account shall be taken of the number of grilles or diffusers within a space when selecting against NR criteria, and the numerical basis of selections shall be provided.

4.4.1.2 Grilles & Diffusers

All grilles and diffusers, except where mounted on exposed ducts, shall incorporate a full perimeter resilient sealing strip.

Where lever adjustment of control is necessary, the lever shall be removable.

Natural finish aluminium alloy items exposed to atmospheric corrosion shall be protected to prevent long-term deterioration in appearance.

Plenum boxes shall be supported directly from the building structure and in accordance with the air diffuser manufacturer's recommendations.

4.4.1.3 Displacement Diffusers

Displacement diffusers shall be of galvanized mild steel sheet construction with perforated face panels, air straighteners, base plate and circular connection collar for ducts.

4.4.1.4 Floor Diffusers

Floor diffusers shall be mounted flush with the finished surface, have removable grilles or dirt collection baskets to permit cleaning.

Point loading shall be appropriate for the application.

4.4.2 Weather Louvres

4.4.2.1 General Requirements

Air intake and discharge openings shall be fitted with framed weather louvres designed to prevent ingress of rain and to minimise pressure losses.

Louvres shall be tested to BS EN 13030. The minimum water penetration performance required is Class B unless otherwise indicated.

The air velocity across the core of louvres shall not exceed 2.5 m/s and the pressure drop shall not exceed 50Pa unless otherwise indicated.

Ductwork and plenum immediately behind an intake or exhaust louvre shall be painted on all internal and external surfaces for a distance from the louvre equal to the louvre height or to the nearest equipment item, whichever is the lesser. The paint is to be selected for wet/dry alternating conditions (epoxy resin or bitumastic paint) and shall have a minimum life to first maintenance of 10 years. The bottom side of the ductwork connection shall have a 15° minimum slope towards the louvre and arranged to drain out through the louvre.

Any carried-over moisture shall be contained by an adequately sized closed-end gutter section at the bottom of each louvre or louvre section. Drain gutters shall have an outlet branch piped to the nearest gulley or to discharge on an adjacent drained roof as applicable.

Frames shall be positively fixed by bolting to structural members and weather sealed and acoustically sealed into openings with a suitable mastic. Flanges shall fully mask the opening.

Sound power level of regenerated noise due to airflow through louvres shall be measured in octave bands according to BS EN ISO 5135 or an equivalent approved by the acoustician.

4.4.2.2 Materials & Construction

All materials, including fixings, shall be corrosion resistant or treated to resist corrosion.

Frames and blades fabricated from galvanized mild steel or aluminium sections and sheet shall normally be bolted together. If welding methods of assembly are used the galvanizing shall be reinstated immediately on completion of welding. Aluminium used for all major components shall be recycled.

Frames and blades fabricated from aluminium alloy extruded sections shall be inert gas shielded arc-welded, or bolted or riveted together.

Galvanized wire bird screens shall be fitted to the inner face of louvres, shall be removable for cleaning, extend over the full face of the louvre and be of 10mm mesh size.

4.4.3 Acoustic Louvres

Louvres shall have a rigid casing housing double-skin metal blades with plain top surfaces and shaped perforated undersides to achieve maximum attenuation.

Acoustic infill material shall be odourless, non-hygroscopic, non-toxic and non-combustible, not decompose nor support fungal growth and not attract vermin or rodent attack. The infill shall be packed in sealed plastic membrane containers.

Sound reduction index of acoustic louvres shall be tested in octave bands to BS EN ISO 10140-2 in a laboratory conforming to BS EN ISO 10140-5 and rated according to BS EN ISO 717-1. Certified test data shall be obtained.

4.5 THERMAL INSULATION

4.5.1 General Requirements

Provide all labour and materials required for thermal insulation and associated finishes for plant, equipment, pipework and ductwork systems. Finally clean off all materials and finishes.

Thermal insulation shall be installed in accordance with this Specification and TIMSA guidance notes and recommendations. The most onerous requirements shall apply.

4.5.2 Performance & Standards

All thermal insulation shall achieve a minimum 'A+' rating against the Green Guide to Specification and shall be sourced from a supplier who has ISO 14001 certification for the product manufacture and ISO 14001 for the supply chain process.

Requirements for thermal insulation systems (including insulation, sealants, finishes, fixings, etc) and methods of application used shall be to BS 5422 and BS 5970. The recommendations given in the code of practice shall be applied. Definitions of terms shall be to BS 3533. Calculations shall be to BS EN ISO 12241.

The minimum thickness of insulation for conservation of fuel and power shall be not less than that required to achieve the maximum permissible heat losses given in the TIMSA HVAC Compliance Guide (and BS 5422). Standard temperatures used for compliance calculations shall be described in the TIMSA HVAC Compliance Guide (and BS 5422), summarised below.

Table	Application	Principal Function	Outer Surface Emissivity	Ambient Air Temperature (°C)	Contents Temperature (°C)
2	Hot Water Pipework	Conservation of Fuel & Power	0.05	15	60
2	Low Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	75
2	Medium Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	100
2	High Temperature Heating Pipework	Conservation of Fuel & Power	0.05	15	125
2	Refrigeration Pipework	Conservation of Fuel & Power	0.05	25	0
2	Chilled Water Pipework	Conservation of Fuel & Power	0.05	25	5
2	Cold Water Pipework	Conservation of Fuel & Power	0.05	25	10
2	Warm Air Ductwork	Conservation of Fuel & Power	0.05	15	35
2	Cool Air Ductwork	Conservation of Fuel & Power	0.05	25	13

The minimum thickness of insulation for control of condensation and frost protection shall be not less than that required by relevant tables in BS 5422 and the TIMSA HVAC Compliance Guide. Standard temperatures described in BS 5422 and the TIMSA HVAC Compliance Guide are summarised below.

Table	Application	Principal Function	Outer Surface Emissivity	Ambient Air Temperature (°C)	Relative Humidity (%)	Contents Temperature (°C)
5	Refrigeration Pipework	Control condensation	0.05	25	80	-40 to 0

Table	Application	Principal Function	Outer Surface Emissivity	Ambient Air Temperature (°C)	Relative Humidity (%)	Contents Temperature (°C)
8	Chilled Water Pipework	Control condensation	0.05	25	80	5
8	Chilled Water Pipework	Control Condensation	0.05	25	80	10
10	Chilled Air Ductwork	Control condensation	0.05	25	80	10
23	Commercial & Industrial Freezing	Inhibit freezing		-10 (12hrs)		2
24	Domestic Freezing	Inhibit freezing		-6 (8hrs)		2

Where the thickness is not a commercially available size, the nearest larger size shall be selected.

The required minimum thermal conductivity and other performance requirements of insulating materials and systems may also be as specified on the Equipment Data Sheets.

When insulating for more than one purpose the most stringent design parameters apply.

Vapour barriers, finishes and cladding shall not be deemed to contribute to the overall insulating effect or material thickness.

Vapour barriers shall be provided on all services operating below ambient air temperature. Vapour barriers shall be of required permeance for the system operating temperature. The permeance shall not exceed 0.004g/(s.MN) for chilled water and chilled air applications. Vapour barriers shall be sealed and maintained continuous to prevent the passage of water vapour.

Unless stated in the Fire Strategy, insulation materials must achieve a Class 0 rating for insulating materials shall be as defined in BS 5422 Annex E and tested in accordance with BS 476 parts 6 and 7, or Class B-s3, d2 as defined in BS EN 13501-1. Fire resistance shall be maintained where services pass through fire compartments.

Manufacturer's certified performance data for materials shall be submitted to demonstrate compliance with BS 5422.

Thermal insulation systems shall be applied in accordance with British Standards, manufacturers' recommendations and any particular requirements given in the Specification.

4.5.3 Applications

4.5.3.1 Energy Conservation & Temperature Control

Thermal insulation shall be applied to limit of heat loss or heat gain, prevent condensation, and ensure fluids are delivered at required conditions at point of use.

4.5.3.2 Personnel Protection

Insulation shall be provided to restrict surface temperatures to the requirements of BS 5970 and the TIMSA HVAC Compliance Guide.

4.5.3.3 Frost Protection

Thermal insulation, in combination with electrical trace heating tape as necessary, shall be applied where freezing is likely to occur.

4.5.3.4 Condensation Control

All services operating below ambient air temperature shall be insulated to prevent surface condensation unless more stringent requirements apply.

4.5.3.5 General Application Schedule

Plant, equipment and services shall be insulated to conserve energy, maintain temperature control, protect personnel, prevent freezing, and control condensation including typical applications and functions given below.

Application	**Energy Conservation**	**Personnel Protection**	**Frost Protection**	**Condensation Control**
Supply Air Systems	✓			✓
Return Air Systems	✓			
Recirculation Air System	✓			
Air Handling Units	✓			✓
External Louvre Plenums	✓			✓
Air Diffuser Plenum Boxes	✓			✓
Heating Pipework Systems	✓	✓	✓	
Heating Pumps	✓	✓		
Steam & Condensate Pipework Systems	✓	✓		
Refrigerant Evaporators & Pipework Systems	✓	✓		✓
Chilled Water Pipework Systems	✓		✓	✓
Chilled Water Pumps	✓			✓
Condenser Water Pipework Systems			✓	✓
Cold Water Pipework Systems	✓		✓	✓
Cold Water Pumps			✓	✓
Water Heaters & Storage Cylinders	✓	✓		
Hot Water Supply Pipework Systems	✓	✓	✓	
Boilers & Boiler Feed Tanks	✓	✓		
Flue Systems	✓	✓		✓
Heat Exchangers (Hot)	✓	✓		
Heat Exchangers (Cold)	✓	✓		✓
Storage Vessels (Hot)	✓			
Storage Vessels (Cold)	✓			✓
Storage Tanks & Cisterns			✓	✓
Water Treatment Plant	✓			✓
Internal Rainwater Pipework				✓
Notes For the purposes of this table pipework system means pipelines, headers, and all associated equipment and fittings. The requirements apply to internal and external services.				

Mineral fibre insulation shall not be used in aseptic areas or kitchen and food preparation areas.

4.5.4 Materials

4.5.4.1 General Requirements

Insulating materials shall be new and to BS EN 13166, BS 3958 and BS 5422.

Insulating materials shall be supplied by a member firm of the Thermal Insulation Manufacturers and Suppliers' Association (TIMSA).

Insulating materials shall be applied in accordance with BS 5970, and manufacturer's recommendations.

Physical characteristics and fire performance of materials shall be to BS 5422.

Insulating system materials shall be suitable for system maximum and minimum temperatures and long term service under normal operating conditions. Insulation system operating temperature limits shall be confirmed by the manufacturer.

Insulation materials and finishes shall achieve Class 0 rating as defined in Approved Document B and tested in accordance with BS 476 parts 6 and 7, or Class B-s3, d2 as defined in BS EN 13501-1.

Insulating materials shall have a zero ozone depletion potential (ODP) rating.

Insulating materials with a global warming potential (GWP) of 5 or more, either in manufacture or in composition, shall not be used.

Closed cell type insulation shall be used for pipework services, associated vessels and equipment, and low temperature air handling systems operating at or below ambient air temperatures.

Direct contact of dissimilar metals shall be avoided. Wire netting reinforcement shall not be used in contact with stainless steel.

Products and materials, and work associated with the manufacture, handling, preparation and installation shall comply with guidance provided by the HSE and current regulations.

4.5.4.2 Man-Made Mineral Fibre Materials

Man-made mineral fibrous material (mineral fibre) shall be to BS 3958. Preformed pipe sections shall have a thermal conductivity not exceeding 0.037W/mK at 50°C and slab 0.033W/mk at 10°C. Mineral fibre materials shall be contained or stabilized by bonding or covering to prevent fibre migration from unintentional physical contact or erosion by air-flow.

4.5.4.3 Phenolic Foam

Phenolic foam preformed insulation shall be to BS EN 13166, Type A, free of water-soluble chlorides, with factory-applied bore coating. Phenolic foam shall have an 'aged' thermal conductivity not exceeding 0.021W/mK at 10°C.

4.5.4.4 Expanded Nitrile Rubber

Expanded nitrile rubber shall have an 'aged' thermal conductivity not exceeding 0.037W/mK at 20°C. Water absorption shall be less than 1.5% maximum by volume over 28 days. Resistance to oils and greases shall be 'high' and resistance to ozone (ASTM-D-1171) shall result in 'no cracking'. The material shall incorporate a smooth external impermeable barrier surface.

4.5.4.5 Cellular Glass

Cellular glass preformed insulation shall have a thermal conductivity not exceeding 0.042W/mK at 10°C (and 0.048W/mK at 10°C for load bearing sections). It shall have a density of 120kg/m3 (135kg/m3 for load bearing sections) and be free from water soluble chlorides.

4.5.4.6 Calcium Silicate

Calcium silicate shall comply with the physical requirements of Type 1 material to BS 3958-2. Calcium silicate shall have a thermal conductivity not exceeding 0.061W/mk at 100 °C.

4.5.4.7 Adhesives & Mastic Sealants

Adhesives and mastic sealants used shall be suitable for the operating environment in which they are used.

The use of solvent-based adhesives on site shall be restricted as practicable.

4.5.4.8 Finishes

Insulation shall be faced with factory applied reinforced aluminium foil laminate unless otherwise specified.

Aluminium-zinc coated steel sheet shall have a minimum coating weight to BS 5970.

Stainless steel sheet shall be to:

- AISI Grade 316.
- DIN 17440.
- An agreed equivalent.

Poly-isobutylene (PIB) sheet shall not be less than 0.8mm thick.

Semi-rigid PVC sheet shall not be less than 0.35mm thick.

Expanded nitrile rubber shall be finished to suit the application in accordance with manufacturer's recommendations.

Polymeric mastic coatings shall be applied as recommended by the manufacturer for the application in which they are used.

4.5.5 Installation

4.5.5.1 General Requirements

Insulation systems shall be installed in accordance with BS 5970 and manufacturer's recommendations.

Insulation shall be applied to dry, clean surfaces. Where vapour barriers or weatherproof finishes are to be applied, the insulation shall be kept dry until covering is complete.

Insulation shall not be applied to pipework, ductwork and associated equipment items until all pressure and leakage tests have been satisfactorily completed and documented, and surfaces cleaned and painted where required.

Insulation shall be applied to ensure that full surface contact and constant thickness are maintained. Pre-formed bends shall be used to ensure accurate fit. Where mitred sections have to be used, pieces shall be cut and fitted accurately using the minimum number required. All joints shall be firmly butted together. All individual sections shall be securely fixed.

Insulation thickness shall be increased over flanged joints, connections, fasteners, stiffeners and other assembly components to maintain appropriate cover.

Where necessary, full insulation thickness shall be achieved by multi-layer application with staggered joints.

Insulation in sheet, slab or mattress form shall be fixed with adhesive and suitable mechanical fixings (hangers, aluminium bands, wire mesh, etc) to ensure that long-term full surface contact is maintained.

The outer surface of installed work shall be firm and present a smooth and unbroken appearance. Adjacent services or items of equipment shall be insulated separately and clearances between services maintained.

All necessary attachment and support devices shall be provided and fixed. Fixings used shall ensure insulation thickness is maintained and prevent settlement and sagging of insulation material. Fixings shall be corrosion resistant.

Insulation at load bearing support inserts shall be of rigid, non-combustible material of same thickness as adjoining insulation. The thermal performance of support inserts shall be at least equivalent to adjoining insulation. Support inserts shall be durable and suitable for longterm service. Support inserts shall be extended by a minimum of 50mm each side of the support to permit sealing the vapour barrier.

All metal cladding, exposed reinforcement and other metallic components shall be bonded to a suitable earth connection.

Provisions shall be made to accommodate thermal expansion and contraction, including recommendations given by BS 5970.

Instruments, gauges and isolating cocks, other fittings and connections shall be clear of the insulation.

Where existing cooling plant must remain in operation, surfaces shall be defrosted as necessary with methanol, or equivalent, immediately before application of insulation and a vapour seal applied immediately following. Care shall be taken when handling defrosting agents.

Cellular glass sections shall be secured with 12.7mm wide 0.5mm thick BS 304 S16 stainless steel straps at 300mm centres. Wire shall not be used to support or secure cellular glass insulation.

4.5.5.2 Vapour Barriers

Vapour barriers shall be maintained continuous throughout each entire system. Vapour barriers shall be carried across equipment, fittings, and pipe inserts.

Vapour barriers shall have an overlap of at least 40mm and shall be sealed by a waterproof adhesive or mastic.

Vapour barriers along pipe sections shall be sealed directly to pipework either side of fittings to prevent moisture ingress during maintenance.

Cellular glass insulation shall be vapour sealed at all joints and around the bore using a suitable mastic sealant in accordance with manufacturer's recommendations.

4.5.5.3 Adhesives & Self-Adhesive Tapes

Adhesives and self-adhesive tapes shall only be applied to dry, clean surfaces. Adhesives and self-adhesive tapes shall be suitable for the environment in which they are used.

Surfaces on which self-adhesive tapes are applied shall be primed with a compatible contact adhesive prior to application of the tape. Self-adhesive 'soft' tapes which do not ensure satisfactory long-term adhesion shall not be used.

4.5.5.4 Pipework

All pipework and fittings shall be insulated and shall be continuous over all fittings and couplings unless otherwise indicated.

Pipework shall be insulated with pre-formed pipe sections.

Pre-formed mineral fibre and phenolic foam sections shall have a factory applied fully bonded reinforced aluminium foil facing with integral longitudinal self-adhesive lap.

Closed cell insulation shall be used for services operating below ambient air temperature.

Expanded nitrile rubber tube shall achieve Class 0 rating as defined in Approved Document B and tested in accordance with BS 476 parts 6 and 7, or Class B-s3, d2 as defined in BS EN 13501. All joints shall be continuously sealed with adhesive and additionally sealed with self-adhesive tape.

Pipe sections shall be secured additionally with 50mm wide self-adhesive aluminium foil tape, or aluminium flat bands, at 300mm centres. Formed bends shall be banded twice on each segment.

Insulation at and adjacent to flanges shall use oversize pipe sections and be arranged to allow the removal of fixing bolts and nuts without damage to insulation or finishes.

Pumps, pipe fittings and removable assemblies shall be insulated and vapour sealed as adjacent pipework. Vapour barriers shall be maintained continuous.

Pipe expansion devices shall operate without interference by insulation which shall be carried over such devices on close-clearance sheet metal sleeves secured at one end only.

4.5.5.5 Ductwork

Rectangular ductwork which is to be exposed or clad shall be insulated with rigid slab material. Slabs on horizontal faces shall overlap those vertical faces to maintain thickness at corners.

Circular and flat oval ductwork which is to be exposed or clad shall be insulated with rigid slab and preformed sections or lamella mattress.

Rectangular, circular and flat oval ductwork which is 'concealed' shall be insulated with rigid slab or mineral fibre mattress.

Mineral fibre mattress shall be secured with 150mm wide bands of suitable adhesive at 300mm centres and wrapped with a full retaining, non-penetrating, wrap of zinc-coated hexagonal steel wire netting with joints laced with 1.6mm bright soft steel wire.

All joints shall be securely sealed with 100mm wide soft aluminium tape.

Drop rod fixing to bearer supports of suspended ductwork shall leave sufficient clearance for application of insulation, vapour barrier and finish covering to the duct sides.

Proprietary or custom-made access doors, covers and panels shall have insulation equivalent to the adjoining ductwork.

4.5.5.6 Storage Vessels & Heat Exchangers

Storage vessels and heat exchangers shall be insulated with preformed insulation.

Insulation shall be firmly secured in accordance with manufacturer's recommendations and BS 5970.

4.5.5.7 Tanks & Cisterns

Water storage tanks and cisterns shall be factory insulated.

4.5.5.8 Hot Water Storage Cylinders

Hot water storage cylinders shall be factory insulated.

4.5.5.9 Removable Covers

Removable covers (e.g. access panels, inspection covers, etc) shall be insulated, vapour sealed and finished to the same standard as the service or equipment in which they are located. Pipe fittings shall be insulated with proprietary, removable, flexible jackets, vapour sealed and finished to the same standard as the service in which they are located.

4.5.6 Finishes & Cladding

4.5.6.1 General Requirements

Finishes and cladding shall be provided in accordance with the recommendations of BS 5970.

All joints shall have 40mm minimum overlaps. All laps shall be securely fixed.

Finishes shall be formed to closely fit to the outside dimensions of the insulated work to achieve a neat, lineable appearance. Cladding shall be fitted with longitudinal seams turned away from the major direction of view.

All cladding shall be self-supporting and shall not contact metal surfaces or attachments.

The vapour barrier shall not be used as the final surface finish if it is likely to be damaged.

No cladding fixing or retaining devices shall penetrate vapour barrier material.

Methods of fixing used shall accommodate movement due to thermal expansion.

Exposed edges and corners of insulation slabs shall be fitted with protective cappings.

Test point and fixed instrument penetrations to rigid finishes shall be fitted with purpose-made, close-fitted cover plates or split discs of casing material secured with closed pop-rivets at 75mm centres and/or suitable adhesive.

All sheet cladding used for weatherproofing shall have overlaps at joints arranged to shed water. External penetrations shall have covers lapped and sealed to exclude water. Top surfaces of weatherproofed ductwork shall be arranged to fall to shed rain water and prevent ponding.

4.5.6.2 General Application Schedule

Unless otherwise specified on the Equipment Data Sheets, finishes and cladding shall be provided as listed below.

Service/Equipment	Location	Finish/Cladding
Pipe work and ductwork systems.	Concealed voids (ceiling voids, floor voids, risers, etc)	Reinforced aluminium foil.
Pipework and ductwork systems.	Exposed to view.	Reinforced aluminium foil and embossed aluminium sheet.
Pipework and ductwork systems greater than 2m above floor or access deck level and where no mechanical damage is likely.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil.

Service/Equipment	Location	Finish/Cladding
Pipework and ductwork systems less than 2m above floor or access deck level.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems where mechanical damage is likely.	Plantrooms, plant access areas, risers.	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems	External routes and plant areas where foot traffic is likely	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.
Pipework and ductwork systems	External routes and plant areas where no mechanical damage is likely	Polyisobutylene sheet.
Vessels, heat exchangers, calorifiers	Plantrooms	Reinforced aluminium foil and embossed aluminium or 'Aluzinc' sheet.

4.5.6.3 Reinforced Aluminium Foil

Reinforced aluminium foil shall have 40mm overlap at joints fixed down with suitable adhesive.

4.5.6.4 Sheet Metal Cladding

For normal applications the thickness of sheet metal cladding shall not be less than given in BS 5970, Table 7. The thickness shall be increased where the underlying insulation is compressible.

Lapped joints shall be secured by pop rivets or self tapping screws fixed at 150mm centres. Where a vapour barrier is required a resilient strip of insulating material of thickness 1.5 x screw depth shall be fitted to absorb the screw penetration. Alternatively the cladding shall be secured by metal straps at 225mm centres. Overlaps shall be a minimum of 100mm for ductwork.

Circular bends over 200mm outside diameter may be clad with equal segmental pressed or formed sections.

Cut edges on galvanised sheet steel shall be cleaned and painted with zinc-rich paint.

4.5.6.5 Poly-isobutylene Sheet

Poly-isobutylene (PIB) sheet shall be lapped to shed water with 75mm minimum overlaps at all joints, and shall be secured and sealed with adhesive or by solvent welding to provide a weatherproof vapour-resistant finish.

Poly-isobutylene sheet shall be retained to prevent sagging.

4.5.6.6 Polymeric Mastic Coated Mineral Fibre

Proprietary mastic coated mineral fibre sheet finish systems shall be applied in accordance with manufacturer's recommendations and shall be secured with one coat of mastic and have 50mm minimum overlaps at all joints. For insulation located internally, a finish coat shall be applied to the entire surface. For external locations, two top coats shall be applied. Each coat shall be of a different colour to indicate correct application. Where insulation is exposed to view a decorative finish shall be provided.

4.5.6.7 Polymeric Mastic Coated Cellular Glass

Proprietary SM polymer coated cellular glass finish systems shall be applied in accordance with manufacturer's recommendations for internal and external locations. Where insulation is exposed to view a decorative finish shall be provided.

4.5.6.8 Pumps & Pipe Fittings

Pump bodies shall be encased in prefabricated, removable, metal casings with quick release clips. All metal edges shall be folded during factory assembly. Casings shall match the pipe cladding.

Where adjacent pipework is finished with sheet metal, valves, flanges, strainers, and any other fittings that require routine access, shall be fitted with proprietary removable, formed insulation casings secured with spring release clips. Casings

shall match the pipe cladding. Casings shall not impair valve operation. Provision shall be made for removal and refitting securing bolts without damage to insulation or finishes.

Fittings, valves and pump bodies casings shall be formed of a minimum number of sections. Components shall be sealed using a non-setting compound.

4.5.6.9 Storage Vessels & Heat Exchangers

Insulated storage vessels and heat exchangers shall be encased in 1.2mm sheet. Joints shall be secured by aluminium pop-rivets or sherardised self-tapping screws at 50mm maximum centres, all finally secured with 25mm wide bright aluminium tensioning bands at 450mm maximum centres.

Insulation below 450mm above floor level shall be fitted with 1.6mm thick sheet metal 'kicking strips'.

4.5.6.10 Removable Covers

Custom-made access panels shall have insulation contained within a channel section frame to ISO 6362 with mitred corners. Facing panels shall be formed from sheet metal a minimum of 1.6mm thick and shall be bedded in mastic.

4.6 NOISE & VIBRATION

4.6.1 Surveys

All acoustics measurements shall be made by a qualified acoustician.

Measurements shall be made using a Class 1 sound level meter complying with BS EN 61672: Part 1 (IEC 61672-1). Meters shall be calibrated in accordance with BS EN 61672 – 3 (IEC 61672-3) using a calibrator complying with BS EN 60942 (IEC 60942).

Sound level meters and calibrators used shall hold a valid calibration certificate issued by a United Kingdom Accreditation Service (UKAS) accredited calibration laboratory.

Equipment calibration shall be checked prior to the start of any series of tests. The calibration shall be rechecked on completion of the test sequence. Any drift in calibration shall be recorded.

Measurements shall be taken with the microphone in free space between 1.2 and 1.5 metres from the floor, and 1.5 metres from walls or other large sound reflecting surfaces within the room, but in small compartments the details of the measurement positions shall be included in the test data. The microphone shall be located at a point not less than 2 metres from any 'small' identified sound emitting surface or point (e.g. grilles, diffusers, ducts, etc). For 'large' surfaces (e.g. louvres, etc) the measurement distance shall be not less than 3 metres. Site variations imposed shall be recorded. Measurement duration shall be compatible with the type/characteristic of the source in order to achieve a truly representative record.

Sound pressure levels of internal noise fields shall be determined from measurements taken from five (minimum) randomly chosen points in the area under test. Sound pressure levels of external noise fields shall also be determined. Results for both internal and external noise fields shall be compared with specified levels.

Vibration transducers used for building and external ambient vibration measurement shall be accelerometers with a 'flat' response between the design operational limits. The sensitivity of the accelerometer to vibrations in the design direction of measurement shall be at least 20 times the sensitivity in perpendicular directions.

Vibration measuring equipment used for surveys of electric motors and equipment shall be to BS 4675-2, (ISO 2954) and BS EN 60034-14, except that accelerometers rather than velocity transducers may be used when making comparisons of building and machine vibrations.

Full survey results shall be submitted, including frequency spectra and clear indications of measurement locations. Equipment operating conditions must be fully noted. Measurements of systems under part-load are not representative of full load. Similarly measurements made before commissioning and / or balancing is completed are not representative of final conditions.

4.6.2 Criteria for Buildings & Machinery

4.6.2.1 Vibration - Electric Motors

The 'vibration severity quality grades' in BS EN 60034-14 define the maximum acceptable vibration of any part of the motor in any direction, due to all sources, when tested at works under the conditions of the standard.

Vibration severity grades shall be as follows:

- Motors with 'shaft centre height' greater than 400mm and speeds of 10Hz or more, as Table 2, Column 1.
- Motors with 'shaft centre heights' less than 400mm and speeds of 10Hz or more, Grade 'N' if mounted on concrete slabs in contact with 'unmade-up' ground, Grade 'R' elsewhere.
- Motors operating at speeds below 10Hz, as severity grades (or tabulated values of Table 2) for 10Hz motors.
- Motors in occupied spaces, or on fan convectors, 'canned rotor' pumps etc, vibration velocity limits as for Grade 'R' for motors with shaft heights between 80 and 132mm.

Variable or multi-speed motors shall satisfy the balance quality grade required at highest operating speed.

4.6.2.2 Vibration - Impellers

Rotating impellers of fans, pumps, chillers, etc, shall be balanced to standards not inferior to the balance 'quality grades' of ISO 1940-1 or to the corresponding residual eccentricities. The criteria shall apply to finished impeller and shaft assemblies at delivery.

The balancing quality grades shall be to the following minimum standards:

- Grade G6.3 where the product [impeller mass (kg) x operating speed (Hz)] is less than 250.
- Grade G2.5 where the product [impeller mass (kg) x operating speed (Hz)] is greater than 250.
- Grade G2.5 for impellers on packaged HVAC equipment located in occupied areas with motor power inputs more than 100W or 'canned rotor pumps' or similar.
- Impellers operating below 10Hz shall be balanced as if they operated at 10Hz.

Impellers of multi-speed or variable speed machines shall be balanced to the quality grade determined by their highest operating speed.

Vibration caused by fluid dynamic effects of any kind shall not be greater than the equivalent permissible vibration due to an impeller rotating at the frequency of the vibration.

4.6.2.3 Vibration - Reciprocating Machinery

The following reciprocating machinery shall be located on a ground bearing slab unless a full dynamic analysis of the vibration generated and the building response permits otherwise:

- Internal combustion engines with shaft powers greater than 40kW.
- Chiller compressors with shaft powers greater than 75kW.
- Single cylinder machines with shaft powers greater than 5kW.

The following reciprocating machinery may be located on concrete floors thicker than 150mm and less than 10m maximum span, but not on any suspended floor in steel or timber framed buildings:

- Internal combustion engines with shaft powers less than 40kW.
- Chiller compressors with shaft powers less than 75kW.
- Single cylinder machines with shaft powers less than 5kW.

4.6.2.4 Vibration - Building Structure

The vibration of the surface of the building due to operation of the building services shall not be perceptible to occupants sitting, standing or lying down in occupied areas and shall not exceed the levels given below:

Type of Area	**Surface Vibration Velocity (Maximum rms mm/s)**
Occupied Areas	0.1
Plantrooms	0.3

Appropriately weighted vibration measurements and/or predicted vibration dose values (VDVs) in all occupied areas shall comply with the ranges given below in accordance with those for a low probability of adverse comment from BS 6472 *Guide to evaluation of human exposure to vibration in buildings, Part 1: Vibration sources other than blasting*.

Place and Time	**Vibration Dose Values for Low Probability of Adverse Comment,** $m \cdot s^{-1.75}$
Residential buildings 16 hour day	0.2 to 0.4
Residential buildings 8 hour night	0.1 to 0.2

Offices and Retail, 16 hour day	0.4 to 0.8
Workshops 16 hour day	0.8 – 1.6

Specified NR levels shall not be exceeded as a result of vibration of the building surfaces at audible frequencies.

4.6.2.5 Noise Levels - Occupied Spaces

The noise criteria specified shall be met when the building is fully furnished and equipped, and when rooms and other enclosed spaces are unoccupied and when only the building services are operating and at their highest likely noise level.

In specific cases where a required range of noise levels is specified, the noise level shall be within the criterion range across all operating conditions.

NR criteria shall be as defined by BS 8233 Annex B.

dB(A) noise weightings are defined by the requirements for 'sound level meters with weighting networks' of BS EN 61672-1 (IEC 61672-1).

Where equipment is required to meet specified noise limits, the equipment shall be operated at the supplier's works to simulate, as closely as is practicable, the actual operating conditions. Tests shall be made to ensure compliance with the specified levels and to identify any pure tones present. Pure tones detected shall be eliminated. The test method shall be in accordance with the relevant standards and a full test method statement shall be submitted in advance for approval. A detailed test report shall be submitted including full frequency-spectrum results.

Where NR levels are not given for standard rooms and spaces, then CIBSE listed values shall apply.

Pure tones and other narrow bandwidth noise when measured by 3% band width analysis, shall be attenuated by the following amounts below the corresponding octave band sound pressure level permitted.

Octave Band Centre Frequency (Hz)	Attenuation (dB)
63	3
125	5
250	9
500	12
1000	14
≥2000	15

4.6.3 Anti-Vibration Systems

4.6.3.1 Performance

Isolation systems shall restrict vibration and structure-borne noise so that the specified NR levels are not exceeded.

The method of mounting machinery and the size, type and active material of the mountings shall be agreed between machinery and isolator manufacturer.

Design of vibration isolation systems for rotating machinery shall be based on the recommendations of ASHRAE Handbook – HVAC Applications for type of base, mounting, active material and static deflection.

Noise and vibration isolation systems shall be selected to suit the equipment environment. System components located in open air shall be weatherproof, non-rusting and resistant to or protected from rodent and insect attack by choice of materials and design.

4.6.3.2 Variable & Multi-Speed Machinery

Systems shall achieve the degrees of isolation specified at all the normal operating speeds. The resonant frequency of the isolation system shall be lower than any operating speed.

The resonant frequency of isolation systems for machinery and electric motors with stepped speed starting arrangements (star delta, tapped resistor and transformer etc,) shall not correspond to any of the speeds at the step changes and shall allow for long 'run-up' and 'run-down' times.

4.6.3.3 Asymmetrical Loading

The system shall have levelling screws and locking nuts to permit the deflection of each mounting to be adjusted to the design value at the operating condition of the supported equipment.

The maximum difference between resonant frequencies of any two mountings of a set when the supported equipment is operating shall not be more than 15%.

4.6.3.4 Flexible Connections - Fans & Pumps

Vibration isolation systems for fans and pumps shall allow for forces and movement due to pressure differences at flexible connections. Mountings shall be arranged and sized for their loadings at all operating speeds. 'Inertia' blocks and counterweights may be used to reduce the percentage variations in mounting loads at varying speeds.

Isolated sway braces, buffers and similar devices may be used to prevent movement in directions perpendicular to the vibration.

4.6.3.5 Prevention of Overloading

Vibration isolation systems whose mountings can be overloaded by excessive deflections, not caused by the running machine or normal service, shall be provided with 'bottoming' or similar restraints which may be part of the mountings, machinery or bases.

These restraints may be omitted only from vibration isolation systems which cannot be overloaded by pipe or ductwork during erection and which will not be used to assist access.

Vibration isolation systems fitted beneath boilers, chillers, cooling towers or other equipment in which the weight of the liquid contents act through the mountings and forms a significant part of the load, shall be provided with restraints which limit the recovery movement on draining down to prevent strain on service connections or adjacent runs.

4.6.3.6 Supports

Pipes, ducts, and their contents, or other services which are connected, shall be supported to avoid load on equipment items.

Where services are jointed to isolated equipment by flexible connectors and the internal pressure in the connectors is 100 kPa or less, the first three service supports next to the equipment shall include vibration isolators to give 80% efficiency at the fundamental forcing frequency of the equipment, or the efficiency required for services supports in the plant space if it is higher. The supports shall be designed to prevent movement of the connected pipe or duct from static or dynamic forces due to the fluid weight or velocity.

Where piped services are jointed to isolated equipment without flexible connectors, or the internal pressure in the flexible connectors is greater than 100 kPa, the services shall be isolated in accordance with the table below. The table determines the type and extent of isolation on either side of the vibration source for a range of pipe sizes and noise criteria. Where piped services pass through, or are within 5m of, spaces with a criterion of less than NR 35, the pipework shall be isolated in accordance with the table regardless of the system pressure.

Pipe Size	**Category of Isolation Requirement (over a distance of)**		
	Critical *	**Standard ****	**Nominal**
15	RI 10m		
22	RI 15m	RI 7m	
50	PH 30m	RI 10m	

Pipe Size	Category of Isolation Requirement (over a distance of)		
	Critical *	Standard **	Nominal
100	SH + PH 20m + 10m	SH + PH 10m + 10m	PH 10m
150	SH + PH 30m + 10m	SH + PH 15m + 10m	PH 15m
200	SH + PH 50m + 10m	SH + PH 25m + 10m	PH 25m
300	SH + PH 75m + 10m	SH + PH 35m + 15m	PH 35m
KEY: RI - resilient insert within pipe clamp. SH - spring hanger incorporating noise stop pad (static deflection 15mm). PH - hanger incorporating low deflection resilient pad. * 'Critical' areas rated at <NR35 or within 5m of such areas. ** 'Standard' areas rated at NR35-45. Distances given are from the vibration source.			

The category of isolation is determined by the NR levels required in the spaces the system passes through. All plantrooms shall have a 'nominal' category at least.

The first five service supports for ductwork on each side of the vibration source shall also be provided with vibration isolators.

The support vibration isolators shall provide the same static deflection as the equipment supports, for the length of service relating to the first type of the pipe support isolation specification.

In basement plant rooms pedestal supports shall be used wherever possible.

Electrical connections to equipment mounted on vibration isolation bases shall be made through flexible conduit which changes direction by at least 90° in a minimum length of 25 conduit diameters.

Mineral insulated cables shall have one complete turn at 75mm radius or double the permissible minimum radius, whichever is larger.

4.6.3.7 Air Gap Resonance

The width of air gap between undersides of solid machine bases supported on vibration isolation mountings and the floor shall be selected to avoid resonance of the air gap at the major vibrational or acoustic frequencies generated by the supported plant.

The distance between the panels of air handling units and floors, walls, or soffits shall be chosen to avoid resonance of the panel and air gap at the fan or motor rotational and fan blade passing frequencies.

4.6.4 Anti-Vibration Equipment

4.6.4.1 Performance

The selected equipment performance shall meet the requirements of the complete isolation system in which it is used.

Fixing and adjusting of isolators and connectors shall not stress the active elements.

4.6.4.2 Spring Isolators

Spring type vibration isolators shall be constructed from suitably treated and finished steel or steel alloys. All springs shall be open, or unhoused, with a minimum coil diameter of 50mm, manufactured with rubber, neoprene or glass fibre 'acoustic pads' to prevent transmission of high frequencies. The material of the pad shall be selected to suit the location and incorporate a minimum static deflection of 2mm. Holes shall be provided for fixing both to the supported machine and the supporting structure.

The criteria of spring stability under compression shall be that the ratio 'lateral stiffness/vertical stiffness' is at least 1.2 times the ratio 'static deflection/working height'.

Spring type isolators shall have auxiliary dampers or adjustable 'snubber' type restraints which prevent excessive movement as the machine speed passes through the resonant frequency of the mounting system where:

- Static deflection is more than 50mm.
- Isolators are fitted to reciprocating machinery.
- Isolators are fitted to rotating machines with long rundown times.

4.6.4.3 'In Shear' Isolators

Rubber, neoprene, glass fibre or similar material shall be used for 'in shear' type vibration isolators.

The dynamic stiffness and damping coefficients of the active material, at the operating speed of the supported equipment, shall be used in calculation of isolation efficiencies. Alternatively, certified isolation efficiency charts may be used.

Mountings whose stiffness varies with direction of deflection, shall have orientation marks for use during installation and maintenance.

4.6.4.4 Levelling & Height Adjustment

Vibration isolators shall be provided with means of adjustment of deflection to accommodate unevenness in bases, etc, unless located between prefabricated accurately parallel frames. The amount of adjustment for floor-mounted isolators shall not be less than twice the permitted tolerance in the levelling of the floor. Levelling bolts or studs shall have lock nuts.

Alternatively, the 'means of adjustment' may be located between the supported machine and the isolators, or between the isolators and the basic supporting structure.

4.6.4.5 Lateral Stiffness

The lateral stiffness of vibration isolators shall be selected to suit the lateral isolation efficiency required without causing instability. For rotating machines with horizontal shafts, the horizontal stiffness perpendicular to the shaft shall not be less than the vertical, if 'floor' mounted, and vice versa if 'side' mounted.

4.6.4.6 'Pad' or 'Mat' Type Mountings

The material used for 'pad' or 'mat' type mountings may be cellular, ribbed, or studded. Pads and mats shall normally be bonded to both supported and supporting surfaces.

'Pads' or 'mats' of vibration isolation material, used to obtain acoustic isolation in installations which do not require vibration isolators, shall be selected and loaded to avoid resonance. The resonant frequency of the assembly shall not lie between 2/3 and 4/3 of the disturbing frequencies of the supported equipment.

Pads or mats of vibration isolation material, used in 'cast-in-situ' concrete sandwich construction machine bases, shall be separated from the concrete to ensure exclusion of grout and fines from internal voids, as recommended by the manufacturer.

Cork pads or mats shall not be used.

4.6.4.7 Pipe & Duct Hangers

Hangers used for vibration control shall consist of a mild steel welded cage containing a helical spring, neoprene/rubber/glass fibre isolator, or both and shall be suitable for suspension from drop rods. Where both types of isolating elements are used together, the spring shall be at the pipe or duct end of the hanger. The spring or active materials shall be used in compression.

Steel springs shall be stable at all loadings up to full compression which shall not occur before 150% of the rated maximum loading. No permanent deformation shall be caused by full compression. The load shall be transmitted to the spring through a neoprene washer bushed into the moving end to prevent metal-to-metal contact.

Neoprene/rubber/glass fibre isolators shall be protected from overloading by metal-to-metal restraints or lateral containment.

The hanger cage shall be capable of carrying five times the maximum rated normal service load without permanent distortion. The drop rod arrangements shall allow 30mm movement without metal-to-metal contact.

4.6.4.8 Reinforced Flexible Pipe Connectors

Flexible pipe connectors of corrugated metal, or rubber, neoprene or other flexible liner with braided metal or other similar internal or external reinforcing, and intended for use without tie rods, shall have the following minimum live lengths when used for anti-vibration purposes:

Nominal Pipe Bore (mm)	Live Length (mm)
0 - 28	230
32 - 80	340
90 - 133	455
150 - 200	570
250 - 300	690

The minimum internal bore shall not be less than the actual pipe internal diameter.

The axis of the connectors shall be perpendicular to the direction of vibration. Alternatively, where the design allows, the connectors may be formed into 90° bends.

4.6.4.9 Expansion Joints

The tie rod systems on expansion joints used for vibration isolation shall be designed to achieve the isolation required across the joint. The tie rod fixings shall use rubber or neoprene bushed washers to prevent metal-to-metal contact throughout the normal range of movement of the joint.

4.6.4.10 Inertia Bases

Inertia bases shall be constructed from reinforced concrete and shall be designed for the stressing due to the supported machine, the vibration isolation equipment and its own weight. The surface shall be steel float finished or equivalent and levelled to the machine manufacturer's requirements. Machinery shall be fixed to the base with 'grouted in' holding down bolts located in reverse tapered cast sockets.

Where the inertia base will be supported on spring or rubber-in- shear mountings, the base shall be formed with a prefabricated mild steel continuous edge frame, with the necessary cross members and reinforcing. The mountings shall be fixed to brackets welded to the sides of the edge frame.

The brackets and mountings design shall include means to raise the base from the floor and provide for the safe insertion/removal of the mountings without overstressing.

Where the base is cast in-situ on the plant room floor, the bottom shuttering shall be separated from the concrete pour by a continuous polythene sheet.

4.6.5 Engine Exhaust Systems

4.6.5.1 Noise Control

The design sound pressure level to be achieved shall be measured 1m from the exhaust discharge.

The exhaust system shall be separated from the engine exhaust manifold by corrugated bellows. The bellows shall be positioned, after a bend if necessary, with the axis perpendicular to the direction of vibration.

The parts of the exhaust system downstream of a silencer and inside the engine room, or in ducts with other services, or in ducts with duct covers opening into occupied areas, shall have thermal insulation at least 50mm thickness covered with sheet steel of specific weight 10-12kg/m2. The sheet steel sections shall be cut out at supports and expansion joints only and all joints shall be riveted, or made with self-tapping screws.

Constant speed engines shall be fitted with two-stage exhaust noise silencers. The peak attenuation of the first stage shall be at the firing frequency of the manifold to which the exhaust is attached, with a drop in attenuation one octave each side of this frequency not exceeding 5dB. The unit shall be as close to the manifold as possible.

The attenuating characteristic of the second stage shall be complementary to the first and shall cause the spectrum of the exhaust noise at the point of discharge to approximate to the NR specified, within ±5dB over the range of frequencies emitted.

Where there is no restriction in plant space, the second stage attenuator shall be fitted not less than 10 pipe diameters from the first and shall be followed by a tail pipe minimum 10 pipe diameters long. The second stage shall be located in the engine plantroom if the tail pipe passes through occupied spaces.

Where an exhaust system has less than two bends between the flexible bellows connection at the manifold and the point of exit from the plantroom, a second bellows connection, similar to the first, shall be located immediately before the point of exit.

4.6.5.2 Vibration Control

The parts of the exhaust system in the engine plant room shall be supported from vibration isolators. The supports shall allow unstressed expansion of the exhaust system without significant changes in vibration isolator loads or excessive deflections of the flexible connections.

The isolation efficiency at the engine rotational speed (or firing frequency if this is lower) shall not be lower than:

90% when the basic support is a ground slab or retaining wall, or

96% when the basic support is a suspended slab, a column or part of a steel frame type structure.

Isolators shall be suitable for ambient and metal contact temperatures at which they operate.

Supports for tail pipes within permanently unoccupied spaces shall include pads or bushed washers to prevent metal to metal contact between the parts of the support fixed to the tail pipe and the parts fixed to the structure.

Supports for tail pipes within occupied spaces shall include vibration isolators with efficiencies not less than 90% at the firing frequency of the manifold to which the tail pipe is connected.

Intervals between supports shall be selected to give adequate structural support without causing resonance of the supported length at the manifold firing frequency or the engine rotational frequency.

Vertical sections of tail pipes shall be supported at floor slabs, with guides between as necessary to prevent resonance. Horizontal sections shall be run close to junctions of walls and soffits.

4.7 COMMISSIONING & TESTING

4.7.1 General Requirements

Pre-commissioning, commissioning and testing shall be in accordance with the relevant CIBSE Commissioning Codes, BSRIA Guides and this Specification.

All plant, equipment and system components shall be installed, adjusted and set in accordance with the manufacturer's instructions.

4.7.2 Testing

Commissioning and testing shall only be carried out after the installation systems have been statically tested and certified complete, including:

- Works testing of plant.
- Leakage and pressure testing of pipework.
- Air leakage and pressure testing of air handling units.
- Air leakage testing of ductwork.
- Electrical tests to BS 7671.

4.7.3 Systems Cleanliness

4.7.3.1 General Requirements

All systems shall have been cleared of any obstruction and cleaned before commissioning.

4.7.3.2 Water Distribution Systems

All water distribution systems shall have been thoroughly flushed and cleaned as part of pre-commissioning.

4.7.3.3 Air Systems

All ventilation systems shall be completely clear after being 'blown through' using installed fans or by agreed alternative means.

4.7.4 Pre-Commissioning Checks

4.7.4.1 General Requirements

Pre-commissioning checks shall ensure that all system components are correctly installed and are fit for purpose.

All statically complete installations shall be in accordance with the Specification, be free of installation defects, and be clean and safe to operate.

Pre-start up checks shall be made in accordance with the relevant CIBSE Commissioning Codes and the BSRIA Application Guides and documented accordingly.

4.7.4.2 Air Systems

All volume control dampers shall be checked for correct installation, tested for correct operation and then be set in the fully open position.

Fire and smoke dampers shall be inspected for correct installation, tested for correct operation and then be reset. Particular care shall be taken to ensure that the fusible link is functioning properly and its operating temperature is correct.

All dampers, including volume control, fire and smoke dampers, shall be secured in position and covers or access doors marked with the following information:

- Date installation and operation checked.
- Name of checker and checking organisation.
- Parent system, direction of airflow and the unique damper code reference.

4.7.4.3 Water Distribution Systems

Water treatment dosing shall be completed before water balancing commences.

All valves shall be checked for correct installation, tested for correct operation and, except for normally closed valves, be set in the fully open position.

All components, including temperature and pressure test points, commissioning sets, gauges, thermometer pockets, air vents, drains etc, shall be checked for correct location and attitude.

The pressure drop of all pipeline strainers DN 100 and over shall be measured at design flow rate when clean. The results shall be kept as part of the commissioning records and identified on a permanent label attached to the particular strainer.

4.7.4.4 Electrical Wiring

Control panels shall be checked for completion, compliance with the wiring diagrams, and correct identification.

Terminations to all control items and interlocked equipment shall be checked.

All safety and emergency provisions shall be checked and shall be in working order.

Faults shall be immediately rectified.

4.7.5 Regulation Tolerances

Air systems shall be regulated to tolerances appropriate for the system type as described in CIBSE Commissioning Code A. Unless otherwise stated, air system tolerances shall be based on a 'medium' performance effect.

Air systems shall be balanced to minimise noise generation.

Water systems shall be regulated to tolerances appropriate for the system type as described in CIBSE Commissioning Code W. Unless otherwise stated, water system tolerances shall be based on a 'medium' performance effect.

4.7.6 Final Settings

No regulating valve shall be adjusted in excess of the manufacturer's recommendations.

All water regulating devices shall be locked in their final positions in accordance with the manufacturer's approved method.

Final positions of water regulating devices shall be recorded on the particular system commissioning record sheet.

All volume control dampers shall be locked in the final position, and sprayed and permanently marked.

The index terminal shall be clearly identified for each system on the appropriate commissioning record sheet.

4.7.7 System Guidance

4.7.7.1 Variable Volume Water Systems

Two-port valves shall be driven open automatically only to ensure correct seat position is achieved.

Pressure control valves, including differential pressure control valves, shall be commissioned initially with the system fully open and the pump set to maximum design speed, starting closest to the pump and working towards the index point of the system.

The systems shall be proportionally balanced as for a normal constant volume system, with the same tolerances.

Where diversity is applied to the system, part of the system equal the diversified volume shall be closed down during the final scan, and the readings recorded with the system set at 100% flow. The balance shall then be recorded with the diversity changed from the closed 'end' and applied to the other 'end' of the system and the final readings recorded with the system set at 100% flow.

At the conclusion of each stage of the commissioning procedure, the stage shall be witnessed to avoid repeatedly closing down the diversified portion of the system.

To minimise noise generation, the system shall be set at the lowest system pressure required to achieve full design flow at the index terminal, with the system set at 100% design flow (or maximum diversity). In this condition, the pressure shall be recorded at the differential pressure sensors and used as the system operating set point.

The final setting of the differential pressure sensors shall be demonstrated to be controlling the system at the lowest pressure for the index terminal to achieve full design flow with the system set at 100% design flow (or maximum diversity).

10% of the differential pressure control valves shall be functionally demonstrated to show satisfactory operation at part load conditions. Demonstration shall be conducted during final witnessing of system balancing by observation of the branch index terminal flow during subsequent closure of upstream terminal control valves.

4.7.7.2 Variable Volume Air Systems

VAV boxes shall be tested in accordance with the procedure described under 'Option B' of Section C.5.1 of BSRIA AG 1/91.

VAV boxes shall be tested at both Vmax and Vmin settings in accordance with Section C.6.2, paragraph 9a.

A minimum of 5% of VAV boxes shall be further tested in accordance with paragraph 9b (pitot traverse).

Voltage shall be recorded at Vmax and Vmin. Pressure drop shall be recorded from the flow grid where applicable.

To minimise noise generation, the system shall be set at the minimum system pressure required to achieve 100% volume flow at the index box when the system is set at Vmax. In this condition, the static pressure shall be recorded at the system duct-mounted pressure sensors used as the system operating set point.

The final setting of the pressure sensors shall be demonstrated to be controlling the system at the lowest pressure for the index box to achieve design flow at Vmax and Vmin when the system is set at Vmax and Vmin.

4.7.7.3 AHUs - Minimum Fresh Air

Minimum fresh air for VAV systems shall be set up and proven by pitot traverse readings (or equivalent) with fresh air being measured and recorded at Vmax and Vmin, and three positions between, from Vmax to Vmin and from Vmin to Vmax and back to Vmin.

At each point the supply and extract airflow rates shall also be measured and recorded.

The controlled minimum fresh airflow rate shall be demonstrated.

4.7.7.4 Fan Tracking - VAV Systems

Fan tracking shall be proven by pitot traverse readings (or equivalent) made at Vmax and Vmin, and at three positions between, from Vmax to Vmin and from Vmin to Vmax, and back to Vmin. The results shall be recorded.

4.7.7.5 Displacement Ventilation Systems

Smoke shall be introduced into the supply ductwork to prove airflow patterns.

5.0 Appendix 1 – Fan Data Sheet & Drawings for Existing Air Handling Unit (AHU)

nuaire SUMMARY FAN DATA SHEET

Nuaire, Western Industrial Estate, Caerphilly, CF83 1NA, United Kingdom. email:info@nuaire.co.uk
UK Commercial Enquiries T:029 2085 8200 UK Residential Enquiries T:029 2085 8500 International Enquiries T:+44.29 2085 8497

Whilst the information given on this data sheet is fan specific, it is in summary and reference to the product selection catalogue and installation & maintenance documents is recommended.
This data sheet produced on 25 Feb 2021 09:44 using software version 3.7.04 - 9-Jun-2020

Technical Data

XBOXER - Stacked
Pentapost Frame Construction
Heat Recovery Fan

Fan Code:	**S7-XBV-REWP**
Installation Manual Links:	671408
Maximum Fan Input Power:	4.276 kW
Maximum Fan Speed:	4 Pole 1,440 RPM
Electrical Supply:	400 V 3 Phase 50 Hz
Motor Rating:	4.4 kW
Motor Current:	flc: 9 A
Motor Current:	sc: 9 A
Heater Power:	27 kW
Heater Current:	flc: 38 A
Heater+Motor Current:	flc: 47 A

All Ecosmart fans feature soft-starting and stepless variable speed control. A switch disconnector is required to isolate the fan from the electrical supply.

Weight: 680 kg

Sound Data

Acoustic perfomance to ISO 13347 and AMCA 300.

Sound Power Levels re 1 pWatts (Hz):

	63	125	250	500	1k	2k	4k	8k	dBA
Breakout	73	70	75	57	45	45	50	38	46
Induct Intake	75	77	76	74	68	67	65	56	
Induct Supply	81	81	83	84	78	77	75	66	
Induct Discharge	76	71	73	79	72	69	67	53	
Induct Extract	80	83	86	79	74	75	73	69	

dBA is spherical at 3 metres. For hemi-spherical add 3 dBA.

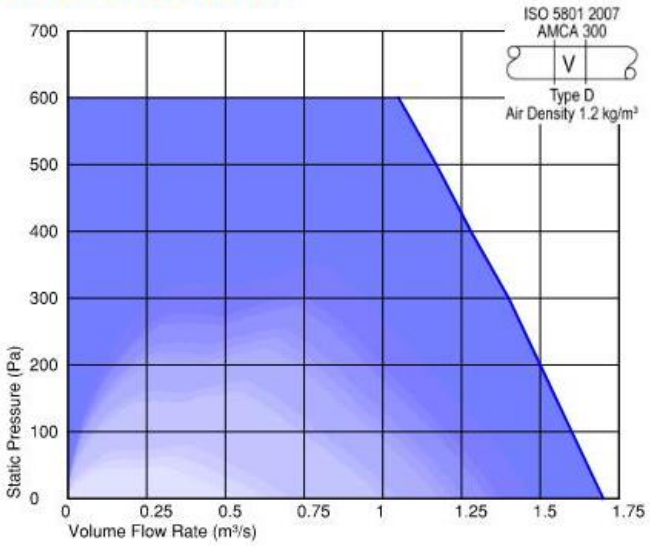
Please note that the noise data stated on this data sheet for the unit and/or silencer is tested in accordance with UK, European and International industry laboratory standards. However onsite conditions may vary and we would recommend that this information is verified by an acoustic specialist in order to ensure its suitability for the intended application.

Specification

The vertical (stacked) unit shall be manufactured from Aluzinc corrosion resistant steel, with 25mm double skinned infill panels and extruded aluminium frame, giving extremely low noise levels. The unit shall include the following items: - a cross flow heat exchanger block with automatic summer bypass, complete with a condensate drip tray and 22mm drain connection. (Alternatively a condensate pump shall be provided if specified.) Supply and extract filters (G4 grade pleated filters) Integral infinitely variable speed controls with minimum and maximum adjustment for accurate commissioning, run on timer and facia mounted failure indication, and interface connections for Ecosmart sensors/enablers, dampers and BMS. The unit shall be constructed with removable panels allowing full maintenance access from the side.

The unit has right hand arrangement in direction of supply air flow. An electric heater battery is fitted, c/w a thyristor heater control. BMS interfaces, fan control and heater battery commissioning control are supplied as part of the Ecosmart control strategy. Heater batteries will require a seperate enable signal from either a variable 0-10V BMS signal or the use of a Nuaire ES-LCD control. The unit shall have low energy, high efficiency EFF2 motor assemblies with sealed for life bearings. The impellers shall be directly driven and of high efficiency centrifugal design. The heat exchanger block will be of high efficiency.

Performance Curve



Unit: S7-XBV-REWP (Right Handed)

PLEASE NOTE: This drawing details the factory-standard unit ONLY (unless silencers are shown too). The total length may differ from that shown depending on the ancillaires offered or if the unit code ends in -QA*****.

KEY

= Denotes location of 700mm minimum access clearance.

= Control Box

VIEW FROM THE SIDE

PLEASE NOTE
FANS AND HEAT RECOVERY SECTIONS WILL BE MADE AND DELIVERED AS ONE COMPLETE UNIT AND NOT IN SECTIONS.
ALL ANCILLARIES, INCLUDING SILENCERS WILL BE DELIVERED ON SEPARATE PALLETS.

VIEW FROM INTAKE END

You can download this CAD drawing from http://www.nuaire.info/CAD/s7-xbv-re_w.dwg

nuaire

Nuaire
Western Industrial Estate
Caerphilly CF83 1NA
United Kingdom
www.nuaire.co.uk

PLEASE NOTE This drawing **must be signed and returned** with official order for manufacturing to be scheduled.
Nuaire will then advise delivery detail with order acknowledgment.
Approval refers to CAD drawing only and not any other images.

ARRANGEMENT APPROVAL

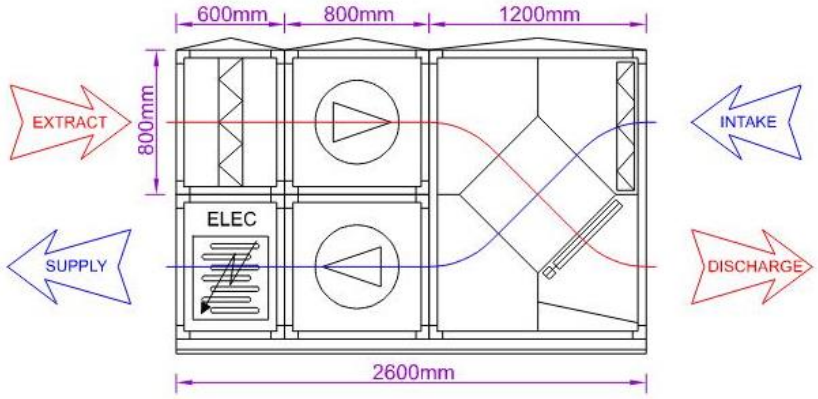
Date: Signature:

Name (please print):

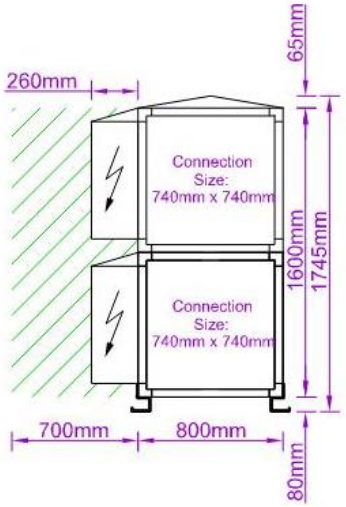
Unit: S7-XBV-LEWP (Left Handed)

PLEASE NOTE: This drawing details the factory-standard unit ONLY (unless silencers are shown too). The total length may differ from that shown depending on the ancillaires offered or if the unit code ends in -QA*****.

VIEW FROM THE SIDE



VIEW FROM INTAKE END



KEY

= Denotes location of 700mm minimum access clearance.

= Control Box

PLEASE NOTE

FANS AND HEAT RECOVERY SECTIONS WILL BE MADE AND DELIVERED AS ONE COMPLETE UNIT AND NOT IN SECTIONS. ALL ANCILLARIES, INCLUDING SILENCERS WILL BE DELIVERED ON SEPARATE PALLETS.

You can download this CAD drawing from http://www.nuaire.info/CAD/s7-xbv-le_w.dwg

nuaire
Nuaire
Western Industrial Estate
Caerphilly CF83 1NA
United Kingdom
www.nuaire.co.uk

PLEASE NOTE This drawing **must be signed and returned** with official order for manufacturing to be scheduled.
Nuaire will then advise delivery detail with order acknowledgment.
Approval refers to CAD drawing only and not any other images.

ARRANGEMENT APPROVAL

Date: Signature:

Name (please print):

6.0 Appendix 2 – Duct Traverse Sheet for Existing Mechanical Ventilation Ductwork

Switch environmental services

Duct Traverse Sheet: Rectangular

Date	30.01.13	Sheet	[redacted]
Project	OKEHAMPTON TOWN HALL		
System	GENERAL SUPPLY AND EXTRACT		
Engineer	S.RODMAN		

4.5	6.2	6.5					
4.6	6.2	6.2					
4.2	6.0	6.7					
3.6	5.3	6.3					
16.9	23.7	25.7					
				Total of Velocities		66.3	

Test Point Location	EXTRACT TOTAL TP		
Duct Size	500	X	400
Duct Area	0.2		m^2
Design Volume	1.000		m^3/s
Average Velocity	5.5		m/s
Test Volume	1.105		m^3/s
% of Design	111		%
Static Pressure	105		Pa

				Total of Velocities			

Test Point Location		
Duct Size		
Duct Area		m^2
Design Volume		m^3/s
Average Velocity		m/s
Test Volume		m^3/s
% of Design		%
Static Pressure		Pa

				Total of Velocities			

Test Point Location		
Duct Size		
Duct Area		m^2
Design Volume		m^3/s
Average Velocity		m/s
Test Volume		m^3/s
% of Design		%
Static Pressure		Pa

				Total of Velocities			

Test Point Location		
Duct Size		
Duct Area		m^2
Design Volume		m^3/s
Average Velocity		m/s
Test Volume		m^3/s
% of Design		%
Static Pressure		Pa

Comments:

7.0 Appendix 3 – 'Bartlett Ltd' Repair Works Quotation

Bartlett Ltd
43-45 Marsh Green Road West
Marsh Barton
Exeter
Devon
EX2 8PT
01392 203000

Customer Address
Okehampton Town Council
Fore Street
Okehampton
EX20 1AA

Quotation

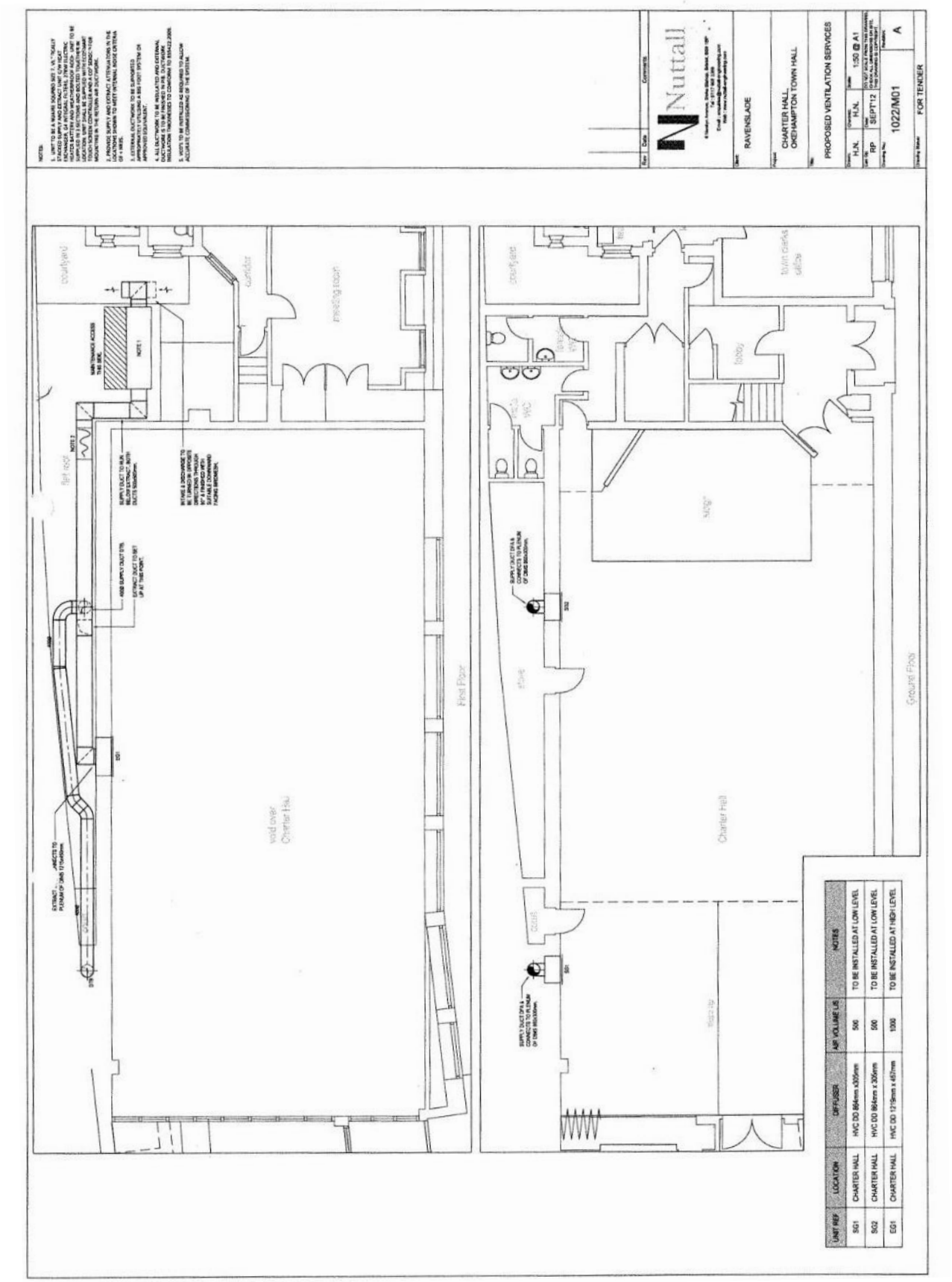
Site Address
<default address>
Fore Street
Okehampton
EX20 1AA

No: 9108
Date: 14/02/2020
Quote Ref: 81910
Customer Ref:
Category: Quote Sent

Qty	Part Ref	Description	Price Each	Price Total
1.00		Labour to replace faulty mains PCB, inverter drive and controller on Nuaire Extract systems as required (2.5 hours at £44 per hour)	£44.00	£110.00
1.00	ES-LCD	ESLCD Controller	£269.17	£269.17
1.00	830152	Main PCB	£254.10	£254.10
1.00	621-1290	ABB Inverter Drive ACS150-03E-05A6-4	£435.33	£435.33

Nett Estimate Total:	£1,068.60
VAT Estimate Total:	£213.72
Gross Estimate Total:	£1,282.32

8.0 Appendix 4 – 'Nuttall' Layout Drawing for Existing Mechanical Ventilation System



9.0 Appendix 5 – Schedule of Manufacturers

Equipment	Preferred Manufacturers / Specialists	Selected Manufacturer / Specialists
Grilles & Diffusers	• Gilberts • Waterloo • Trox Or equal and approved	
Attenuators	• Allaway • Nuaire • Systemair Or equal and approved	

NOTE: The Mechanical Contractor shall complete the relevant sections of the above form and return with their Tender.

10.0 Appendix 6 – Supplementary Drawings & Documentation List

This document shall be read in conjunction with the following mechanical & electrical services drawings & documents referenced within:

Mechanical Drawings:	
OKE-3DE-XX-01-DR-M-57-0001	Existing Mechanical Ventilation Services
OKE-3DE-XX-01-DR-M-57-0002	Proposed First Floor Mechanical Ventilation Services
OKE-3DE-XX-RF-DR-M-57-0003	Proposed Roof Level Mechanical Ventilation Services
OKE-3DE-XX-ZZ-DR-M-57-0004	Proposed Mechanical Ventilation Services Sections & Details
OKE-3DE-XX-ZZ-DR-M-57-0005	Proposed Mechanical Ventilation Services 3D Isometric View
Specifications:	
OKE-3DE-XX-XX-SP-M-57-0006	Mechanical Services Schedule of Works & Tender Summary *(this document)*
Equipment Schedules:	
OKE-3DE-XX-XX-SH-M-57-0007	Equipment Schedule – Attenuators
OKE-3DE-XX-XX-SH-M-57-0008	Equipment Schedule – Supply Diffusers
OKE-3DE-XX-XX-SH-M-57-0009	Equipment Schedule – Extract Grilles

11.0 Appendix 7 – Mechanical Engineering Services – Summary Of Tender

1.	Strip Out & Removal of Existing Redundant Mechanical Ventilation Services	£ _____
2.	Removal & Safe Storage of Existing Air Handling Unit	£ By Main Contractor
3.	New Ductwork Services	£ _____
4.	New Grilles, Diffusers & Ancillaries	£ _____
5.	Controls & Associated Wiring	£ _____
6.	Fire Stopping	£ _____
7.	Testing & Commissioning	£ _____
8.	Preparation & Provision of Working Drawings	£ _____
9.	Preparation & Provision of O&M Manuals & Record Drawings	£ _____
10.	Preliminaries	£ _____
11.	Builderswork	£ By Main Contractor
12.	Contingency	£ 5,500.00
13.	Other (please give details)	£ _____

_____

_____

Mechanical Engineering Services – Total (Excl. VAT) **£** _____

Company Name _____

Name (printed) _____ Date _____

Signature _____

Please return this completed summary of tender direct via email to the project Architect – Mark Kemp, Place Architects, people@placearchitects.co.uk.

~ End of document ~