



RP 14-2

HEATING, VENTILATING AND AIR CONDITIONING - ONSHORE

November 1998

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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of Documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

The value of this Recommended Practice is in the provision of guidance to enable a satisfactory design to be produced by the Design Contractor and the saving of the BP Specialist's time by having these general requirements stated, thus resulting in fit-for-purpose design results.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

This document is based on BP Code of Practice CP 29 (March 1991), having been updated in line with current practice. Although re-formatted into the 'Way Forward' style, users should be aware that many of the prescriptive requirements of BP CP 29 remain, pending possible future detailed review.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSEs, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See [Quarterly Status List](#) for contacts.



1. INTRODUCTION

1.1 Scope

This Recommended Practice is a guide to the specification of Heating, Ventilating and Air Conditioning (HVAC) systems for onshore use. It also specifies BP general requirements for the design, construction, testing and commissioning of HVAC systems, together with materials and equipment to be used, in buildings and plant installations located in any climate world-wide.

1.2 Application of this Recommended Practice

This Recommended Practice should be used by BP and the contractor for guidance during design and the preparation of specifications for equipment purchase.

Users of this Recommended Practice should be aware that further or differing requirements may be needed for individual applications. Alternative equipment or engineering solutions may be considered where appropriate for the individual application. Where an alternative is offered full details should be provided at an early stage to permit full assessment prior to the design freeze.

1.3 Quality Assurance

Verification of vendors' quality systems is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendors to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

Further suggestions may be found in the BP Group RPSEs Introductory Volume.

2. GENERAL REQUIREMENTS

2.1 Design Philosophy

HVAC systems shall be incorporated in buildings and enclosures as required to provide air conditioning, ventilation, heating, pressurisation, cooling and humidity control for the safety and comfort of personnel, for the protection of equipment and to extend the life of stored products.



Specific principles to be followed in a design will be agreed at the outset between BP and the contractor.

External and internal conditions and controls shall be considered at the outset of design in order to develop an appropriate system design solution.

Considerable variations in requirements have been necessary in the variety of premises and installations currently owned and operated by BP. A statement of requirements should be formulated for each project having regard to the particular environmental requirements and local site conditions. It should describe in appropriate detail the engineering requirements as an amplification of this Recommended Practice.

2.2 Design Principles

Design shall be in accordance with international or national standards as appropriate to the specific project. Whilst this RP quotes many standards and practices which will be directly applicable to European and U.K. projects, these should be replaced with equivalent international or national standards and practices as agreed with the Client.

HVAC systems shall be designed to suit the particular application in accordance with the CIBSE and/or ASHRAE Guide Books and shall take into consideration a full assessment of all heat gains, heat storage and heat losses of the buildings or enclosures.

Buildings can be either:-

Heated
Heated and Ventilated
Ventilated
Air Conditioned

Ventilation may be either natural, mechanical or a combination of the two, determined by the specific needs and constraints upon the building or enclosure during the design assessment.

To assist the design contractor, a pro-forma 'Questionnaire' listing basic data to be obtained at the outset of the design will be found in Appendix D.

The Design Questionnaire document is not necessarily complete for any given design and should be extended as appropriate by the designer.



2.3 Sparing Philosophy

For each application an evaluation shall be made of the standby plant required to maintain the service without detriment to the functional needs of the areas concerned.

On essential services equipment, and where space permits, two 100% duty plants (run and standby) shall be installed. Where space restrictions prohibit this then two 50% capacity machines shall be installed. Consideration should also be given on motor driven equipment to one duty plant with two motors. Generally on non-essential services one duty machine will be acceptable.

Plant sparing would typically be as follows:-

<i>Equipment No. and Rating</i>	<i>Service Available on Loss of One Item</i>
1 x 100%	0%
2 x 100%	100%
2 x 50%	60% (approx) +
3 x 50%	100%
3 x 33 1/3%	75% (approx) +
4 x 33 1/3%	100%

+ enhanced performance due to fixed physical characteristics of distribution system operating at part load.

The philosophy for sparing of equipment should be based on a Risk Analysis Study.

2.4 System Selection

2.4.1 General

Selection of the HVAC system will be based on consideration of the following:

- Nature of the application and period of usage of the building.
- Type of building construction.
- External and internal load patterns.
- Desired space conditions and control limits.
- Method of control for minimizing use of primary energy.
- Opportunities for heat recovery.
- Economic factors (including probable future cost and availability of fuel).
- Environment and Health and Safety Legislation.
- Possible need for dilution of contaminants.
- Ease and simplicity of operation and control.



2.4.2 Types of System

Systems suitable for the application should be selected from the following:-

2.4.2.1 Natural Ventilation

Should be selected for unmanned or infrequently occupied buildings where the extremes of weather conditions will not affect the building operation. The buildings will generally require large louvered openings on at least two (opposite) walls together with roof openings or cowls.

To assist the natural ventilation concept and prevent local hot spots and/or gas concentration, specific attention should be given to using a secondary ventilation system termed 'Jet Air'.

Design of naturally ventilated buildings should be in accordance with an appropriate national or international standard.

2.4.2.2 Mechanical Supply/Natural Extract

Should be selected for buildings which cannot be adequately ventilated by natural means or which need to be pressurised due to proximity to hazardous zone or to prevent the ingress of dust, smoke or fumes.

The system should comprise a filtered and heated ducted air supply which is designed to relieve pressure to outside through natural leakage paths or pressure control dampers.

2.4.2.3 Mechanical Extract/Natural Supply

Should be selected for buildings in which local extract is essential to prevent the transfer of odours, heat, fumes or dust produced by the processes contained within the building.

The natural supply or make-up air shall be via louvered openings.

2.4.2.4 Combined Mechanical Supply & Extract

Should be selected for permanently manned buildings to provide proper control of air movement and reasonable control of comfort conditions.

The system should comprise arrangements of supply and extract fans, ductwork, dampers, grilles and diffusers (or common supply fan) with

fresh air intake on the low pressure side. Interconnections may be included for full or partial re-circulation; the fresh air intake provided with filtration and heating as required.

Positive pressurisation control may be provided for non-hazardous areas or enclosures to maintain the design pressure differentials between hazardous and non-hazardous areas, and/or assist in preventing smoke transfer into escape corridors. Fire and smoke control shall be via a local fireman's panel(s) to operate fire/smoke dampers within the ductwork system.

2.4.2.5 Air Conditioning System

Air conditioning systems should be basically similar to the mechanical ventilation systems described in 2.4.2.4 but with the facility for heating, cooling, humidifying and de-humidifying, in order to control temperature and humidity within predetermined limits throughout the year.



3. APPLICATION GENERAL REQUIREMENTS

3.1 General

The systems applications described hereafter generally provide for one basic arrangement which may satisfy a particular application; it is recognised that more than one arrangement may be successfully applied to any particular requirement.

3.2 Offices/Administration Buildings

Large office/administration facilities should have perimeter and internal zones.

Systems selected to serve perimeter zones shall be capable of cooling in summer and heating in winter. During intermediate seasons perimeter zones on one side of the building may require cooling while equivalent zones on the opposite side may require heating, therefore adequate zoning of the system is required.

Note that generally for buildings with glazing area in excess of 60% of external facade, air/water type systems such as induction or fan coil units are more economical than all-air systems and have lower space requirements.

For perimeter zones with small glazing areas, all-air systems incorporating variable volume air flow offer an economical solution.

Internal zones are best suited for all-air systems arranged for high velocity supply to constant or variable volume terminal units, which include secondary attenuation as part of the terminal unit, either single duct or dual hot and cold mixing type.

The units can be arranged for reheat if required.

Recirculation or exhaust air should be designed for low velocity to minimise noise generation.

Specific attention shall be given to diversity of operation to cater for individual control, flexibility of partitioning arrangements and operation outside of normal office hours.

Small and medium size buildings may be suitable for unitary systems, larger facilities are best served by central plant arrangements.

Offices/Administration buildings vary in size and complexity from large, Multi storey structures with extensive glass facades to small single storey flat roof buildings with minimal glazing.

Perimeter zones generally are subject to wide load variations due to daily and annual changes in ambient temperatures and solar radiation.

Factors affecting cooling load in perimeter zones include window area and choice of shading device together with internal gains due to people, equipment and lights.

It should be noted that re-heat and dual duct mixing systems are generally poor with regard to energy conservation.

3.3 Process Buildings

Selection of a suitable HVAC system for process buildings shall consider one or a combination of the following options:-

- Natural Ventilation
- Mechanical Supply/Natural Extract
- Mechanical Extract/Natural Supply
- Full Mechanical Ventilation Throughout
- Full Air Conditioning

Natural ventilation may be applied to hazardous or non-hazardous process buildings provided minimum recommended air change rates are achieved (see 4.4.2). Background heating may be provided by means of steam or hot water unit heaters or indirect heaters if rated to operate in hazardous areas.

Mechanical supply with natural exhaust may be considered for buildings where natural ventilation cannot achieve the minimum recommended air change rates and where outside fresh air can be utilised to limit temperature rise due to process equipment heat gains.

Mechanical extract with natural supply may be applied where it is beneficial to extract at source concentrations of fumes, dust, odours, moisture or heat produced by the process. High capture velocity is desirable. Adequate sources of fresh make-up air should be readily available, tempered in winter to avoid cold draughts and located well clear of extract points to avoid any short circuiting.

Full mechanical supply and extract systems shall be provided for process buildings where natural ventilation cannot provide the air change rates necessary to maintain recommended area pressurisation differentials.

Other influencing factors include the requirements for reasonable control of comfort conditions and proper control of air movement for the benefit of operating personnel and for the removal at source of concentrated air borne contaminants.

All elements of heat recovery should be considered with process mechanical supply and extract systems, particularly where large air flow volumes are involved.

Full air conditioning, in a similar manner to mechanical ventilation systems, but including refrigeration plant shall be provided for process buildings where close control of temperature and humidity are critical to the process.

Process buildings may have varying levels of occupation; the production areas may be hazardous or non-hazardous, and require close control of temperature and humidity depending on the particular process.

It should be noted that supply systems operate most satisfactorily with a complementary extract system.

3.4 Control Buildings

3.4.1 General

3.4.1.1 Heating ventilating and air conditioning systems shall be provided, for the comfort of operating personnel and protection of control equipment.

A minimum of two 50% capacity plants should be chosen.

Consideration should be given to options including low velocity multi-zone units, ductwork re-heat systems, positive pressurisation control and purging ventilation of under-floor cable voids.

In rooms accommodating environmentally sensitive equipment, 2 x 100% capacity split system air conditioning units having external air-cooled condensing units shall be provided to cater for close control of temperature and humidity variables.

These units will therefore deal with the major heat gains, whereas the main HVAC plant will cater for ventilation of service areas, provision of fresh air for occupancy, fire and smoke control and over-pressure in the building.

Where manufacturers of electronic or computerised process control equipment impose rate of change limits on temperature and humidity

within the rooms, the split air conditioning units shall be provided with upgraded thermal controllers incorporating proportional plus integral plus derivative functions accordingly.

Fast-response smoke detection equipment may be required to protect special equipment areas or rooms. Where an extinguishing system is determined as necessary, a pre-action sprinkler should be considered for such rooms, including computer suites. Only in exceptional circumstances should CO₂ protection be considered for individual items of equipment.

Halogen compounds (i.e. Halon 1211, 1301 or other products identified within the Montreal Protocol) shall not be used.

Examples of fast-response smoke detection equipment are Vesda and Hart.

Precautions must be taken to protect personnel if total flood with CO₂ is used. See BP Group RP 24-1 Fire Protection - Onshore.

3.4.1.2 Mode of Operation

(a) Normal

Normally the HVAC plant and room air conditioning units shall operate simultaneously and continuously to maintain conditions and over-pressure in the building.

The controls of the HVAC plant shall modulate the fresh, recirculating and exhaust air dampers to provide an economy cycle, using outside air for cooling whenever suitable.

The Control Room and Equipment Room HVAC Units with higher specification controls will operate to maintain the environmental limits in those rooms.

(b) Emergency

The emergency mode applies when gas or smoke has been detected and operation of the HVAC plant shall then be as follows:-

Gas detected at air intake:-

Air intake and exhaust air gas isolation dampers shall close automatically, the HVAC system shall open the recirculation damper and shut down. The operator may require to operate the system on 100% recirculation and this would be achieved by operating a manual override switch on the HVAC panel.



All external HVAC equipment not certified for operation in a gaseous atmosphere shall be electrically isolated, automatically.

Smoke detected in the building:-

Fresh air and exhaust air dampers shall be opened fully, and the recirculation damper fully closed. The affected area shall be isolated from the HVAC system by manually closing the appropriate fire dampers by means of the Local Fireman's Panel located in the main entrance lobby.

The HVAC system shall continue to operate to purge corridors (which shall be at a higher positive pressure than offices or other areas) and to keep other areas free from smoke/toxic fumes.

The fire fighters will choose whether to continue with this mode of operation or to shut the whole system down, depending upon circumstances.

Coincident gas at air intake and smoke in the building:-

In this event the gas signal shall take priority over the fire signal and HVAC controls shall respond accordingly.

3.4.1.3 Gas Detection/Isolation

Gas detectors shall be provided in the air intake duct. The detection system shall incorporate two out of three voting and be interfaced with the HVAC control panel, via the gas panel. The alarm level for gas detection shall be set at 25% LEL.

Gas isolation dampers provided at the air intake and exhausts shall close automatically on detection of gas at air intake.

3.4.1.4 Fire Dampers

Fire dampers having pneumatic actuator, two electro-pneumatic solenoid valves and frangible bulb shall be provided at fire barrier locations, generally to satisfy the requirements of [BP Group RP 4-4](#) and where required for segregation of an area to be protected by a fire extinguishant system.

The fire dampers shall be remotely controllable from a Local Fireman's Panel to be located in the main entrance lobby of the building. The panel shall incorporate individual switches and status lamps for each fire



damper and override switches for stop and restart control of all HVAC fans.

Secondary fire damper remote control switches should be provided at one of the repeat fire alarm panels, where fitted, to enable operation of the HVAC in the event of the main controls being inaccessible.

3.4.2 Normal Control Buildings

Normal control buildings are those buildings which by virtue of their location remote from hazardous processes are not considered by BP to require any special requirements in accordance with [BP Group RP 4-4](#) section 3.5 'Potential Fire, Explosion or Toxic Hazard'.

3.4.3 Blast-Resistant Control Buildings

All air intakes and exhaust openings shall incorporate suitable arrangements of blast dampers to comply with [BP Group RP 4-6](#).

As far as possible, the HVAC plant and equipment shall be contained within the building.

Equipment which has to be located externally, such as air cooled condensers should be protected by blast resistant barriers.

3.4.4 Special-Design Control Buildings

HVAC provision for special-design control buildings as described in [BP Group RP 4-4](#) Appendix C shall have similar facilities to blast-resistant control buildings but will not be provided with blast protected external equipment or blast dampers.

3.4.5 Air Intakes and Discharges

Where the control building is located so that an unplanned gas release in the plant could reach the building, air intakes and discharges shall be provided with gas isolation dampers, the positioning of the air intake elevation above grade being decided by the type of gas, i.e. lighter or heavier than air.

Air intakes shall be located in the safest position as indicated by a Gas Dispersion Study.

3.5 Computer Suites

Air conditioning shall be achieved by means of two 100% (duty and stand-by) unitary or split system air conditioning units. The units shall



provide constant volume, low velocity reheat recirculation air with between 10% and 15% fresh air make-up. The make-up air shall be allowed to exfiltrate to maintain positive pressurisation and thereby prevent entry of dust or untreated air.

The unitary or split systems shall incorporate a high level of filtration.

Air supply should be overhead through ceiling plenums utilizing perforated face diffusers, linear diffusers or ventilated ceilings as appropriate to provide draught-free conditions.

Portable heaters shall be available to protect the equipment in the event of air conditioning failure and equipment shut-down.

The equipment commonly found in computer suites generates heat and contains components that are sensitive to sudden variations and extremes of temperature, humidity and deposition of dust. Exposure to conditions outwith equipment manufacturers prescribed limits may result in faulty operation or the need to shut-down the equipment.

Computer suites are normally incorporated in Office/Administration or Control Buildings. The requirement for two 100% units is because of the critical nature of computer installations and the need for reliability.

Diffusers or ventilated ceilings permit high air change rates without undue discomfort to personnel.

3.6 Analyser Houses

3.6.1 General

Analyser Houses shall be ventilated with heating and/or air conditioning as required for the safety and comfort of personnel and protection of equipment.

A minimum ventilation rate of 10 air changes per hour shall be provided, sufficient to:-

- (a) dilute escaping vapours from rupture or failure of sample or service lines to less than 20% of the LEL around any potential means of ignition. Particular attention shall be paid to liquids which vaporise at ambient temperatures.
- (b) dilute any toxic gases or vapours released due to failure of any one sample or service in the house to below the OEL.

The ventilation systems may be either natural or mechanical depending on the application.

The minimum ventilation rate of 10 air changes per hour is recommended in the 'Design and Installation of On-Line Analyser Systems', publication No 130 issued by the [Engineering Equipment & Materials Users Association \(EEMUA\)](#).

Occupational Exposure Limits are given in the Health and Safety Executive Guidance Note EH40.

3.6.2 Natural Ventilation

Natural ventilation shall only be considered where the analyser building is located in a non-hazardous area or where all analyser and associated equipment is certified for operation within the classification of the surrounding area. Natural ventilation calculations should consider wind and thermal effects. Louvre openings, two upper and two lower on opposite walls, should be based on the smallest indicated area. Wind calculations should use the minimum average wind speed exceeded for 90% of the year with a gusting rate of 1.6.

To assist the natural ventilation concept, specific attention should be given to the use of a high velocity jet air system to prevent hot spots and/or assist removal of gas concentration.

Resulting ventilation rates should not exceed 50 air changes per hour.

Background heating shall be provided to maintain a minimum of 5°C within the building to prevent any condensation under shut-down conditions.

Natural ventilation will provide limited control of the environment and the area classification within the house will always be the same as the classification of the surrounding area.

3.6.3 Mechanical Ventilation

Mechanical ventilation shall be provided to maintain a minimum positive pressurisation level of +25 Pa under all wind conditions to prevent the ingress of flammable or toxic gases and to assist in limiting the temperature rise in the building due to analyser equipment heat gains.

Mechanical ventilation systems shall comprise two 100% capacity duty and standby plant arrangements with independent power supplies. Ventilation air shall be taken from a non-hazardous area and shall be filtered and heated as required.

Air distribution shall ensure movement throughout the housing and around all the equipment; air exit ports or louvres shall be provided with automatic pressure control dampers.

Temperatures within the house should be controlled at a nominal 20° C. However, heating or cooling, or both, should be provided to maintain temperatures between 10°C and 30°C under extreme conditions with the equipment in operation.

The internal temperature shall not fall below 5°C with the analyser equipment shut down.

The surface temperature of any heaters shall not exceed 200°C under any condition of operation including fan failure.

Under tropical conditions with high ambient humidity the internal temperature should be a minimum of 5°C above ambient to avoid condensation on walls or equipment. Air conditioning with dehumidification shall be considered where this cannot be achieved due to high ambient temperatures. Similarly, air conditioning shall be considered if heat release within the analyser house results in unacceptably high internal temperatures.

Mechanical ventilation systems shall be provided with three gas detectors arranged with a 2 out of 3 voting system to close dampers/shut down the ventilation system on detection of gas. The alarm level of gas detection shall be set at 25% LEL and HVAC system shutdown at 50% LEL. Should the HVAC system contain electric air heaters, the electrical supply to these shall be isolated at 25% LEL.

Ventilation failure shall be detected by means of a pressure differential switch connected across the suction and discharge connections of the duty and standby fans.

Consideration should be given to using intelligent control equipment for fan motor starters.

Gas detection and/or low flow detection shall initiate visible and audible alarms within the house and at a manned remote control station as part of the general alarm/safety shutdown system provided for the analyser house.

For additional information refer to the 'Design and Installation of On-Line Analyser Systems' (see 3.6.1 above).



3.7

Laboratories

The design of HVAC system for Laboratories shall consider:-

- (a) Building configuration - integral part of larger complex or totally separate self contained unit.
- (b) Mode of operation continuous or daily schedule.

In all cases separate designated exhaust systems shall be provided connected to fume cupboards or hoods within the laboratories for the removal of contaminants to atmosphere.

Exhaust systems shall be designed for constant or variable flow. Constant flow shall generally apply to smaller, self contained units. Variable volume shall apply to larger facilities with multiple fume cupboards designed to operate at reduced capacity when not in service.

Exhaust stacks shall be provided if necessary to ensure that exhaust points are well clear of any air intakes and the contaminants are readily dispersed.

Exhaust stack configuration shall depend on the number of exhaust points, toxicity and quantity of discharge, height and location of building.

Make-up air to replace the exhaust flow rate shall be heated or cooled via designated separate air conditioning and refrigeration plant or central systems depending on the building configuration and mode of operation.

Specific attention shall be given to distribution of the make-up air supply system to ensure no draughts are created at the face of the fume cupboards which could reduce their effectiveness.

3.8

Workshops

Provision shall be made for ventilation, heating or cooling of workshops dictated by the local environment and/or the type of work carried out. Conditions in the workshop shall be based upon a non-injurious comfortable environment for personnel, and suitable conditions for equipment.

In some locations, suitable conditions may be obtained using natural ventilating effects via louvred openings at high and low level in the building combined with local recirculating heating units.

Where the foregoing cannot be achieved due to local climate the following services shall be evaluated:-

- (a) mechanical ventilation for safety and comfort of personnel and protection of equipment via two 50% capacity air handling units incorporating filtration and heating (or part of a centralised ventilation system).
- (b) units sized to limit internal temperature rise using outside air as the cooling medium. Local spot cooling effect may be achieved by use of high velocity air jets.
- (c) refrigeration and air conditioning where ambient air temperatures generally exceed internal design temperatures.
- (d) positive pressurisation with relief to atmosphere through pressure relief dampers.
- (e) separate extract fans, ductwork and hood systems for facilities incorporating paint spray booths or welding bays.

3.9 Power Generation Buildings

Power generation buildings shall be provided with independent mechanical supply ventilation systems using outside air to limit the internal temperature rise due to heat gains from the generating equipment; provide aspiration air for combustion purposes (if necessary) and maintain a positive pressurisation level. Ventilation and engine aspiration air shall be derived from a non-hazardous location.

Two 100%, or 3 x 33 1/3% capacity plant arrangements conveying 100% outside air shall be evaluated to provide filtered and heated air as necessary.

Excess ventilation air shall be relieved to outside via pressure relief dampers.

It should be noted that this document does not apply to machinery acoustic enclosures.

3.10 Electrical Sub Stations

Sub stations shall be mechanically ventilated using outside air to limit the internal temperature rise due to heat gains from the equipment. In locations where the ambient conditions or proximity to a hazardous zone precludes the use of mechanical ventilation only, consideration shall be given to the provision of air conditioning/refrigeration systems.

Two 100% capacity or other suitable combination of plant arrangements shall be provided and a positive pressurisation level maintained; air shall be discharged into the space and not directly on to the electrical equipment. The ventilation and cooling supply air shall be filtered to remove airborne contaminants.

Excess ventilation air shall be relieved to outside via pressure relief dampers, or mechanical extract system incorporating pressure control devices.

3.11 Fire Stations

Permanently manned administrative areas of fire station buildings shall be provided with heating, ventilation or air conditioning where this can be justified for the general comfort of personnel.

Where possible the ventilating or air conditioning plant should be independent of main building services to satisfy operational requirements.

Two 50% capacity arrangements shall be provided designed for continuous operation and to maintain a level of positive pressurisation.

Fire fighting vehicle garage facilities shall be naturally ventilated or provided with vehicle exhaust extract systems comprising extract fans and ductwork connected via flexible hoses and nozzles to vehicle exhaust tail pipes.

Heating shall be provided by means of recirculation fan coil units using hot water or electric heater batteries.

3.12 Medical Centres

Medical centres shall be provided with heating, ventilating or air conditioning where this can be justified for the comfort of personnel and well being of patients.

The ventilation or air conditioning service should be an independent system. However, if this cannot be provided main plant HVAC services will suffice.

Independent systems shall comprise two 100% capacity (duty and stand-by) plant arrangements with automatic changeover supplying 100% conditioned outside air to be mechanically extracted with no recirculation.

The systems shall be designed to:-

- (a) control and restrict air movements between departments to reduce risk of cross infection from airborne contaminants.
- (b) provide final stage absolute filtration equipment to remove particulate or gaseous contaminants and airborne micro-organisms.

Air flow patterns in rooms shall be designed to minimize the spread of contaminants; generally pressurisation patterns shall cause an air flow from sterile to less sterile areas in progression.

Sanitary accommodation/toilets shall be maintained at negative pressure relative to other areas to prevent exfiltration of airborne infection.

Ductwork distribution air systems shall incorporate high-level supply with low-level extract/pressure relief.

*** 3.13**

Instrument Marshalling Stations/Local Control Rooms

Mechanical ventilation including heating and filtration shall be provided for the comfort and safety of personnel, protection of equipment and to limit the temperature rise due to equipment heat emission. The system shall comprise two 100% capacity plant arrangements (duty and stand-by) with automatic changeover facility. An alternative could be 2 x 50% capacity units subject to an analysis of 'loss effect' being approved by BP. A positive pressure shall be maintained within the space, fresh air relief being through pressure control dampers to atmosphere.

A mechanically assisted extract system shall be provided if wind effects are frequently severe and likely to reduce effective ventilation/heat removal due to back pressure on relief flaps.



3.14 Switch Rooms

Switch room provisions should conform with 3.1.3 except that heating shall be restricted to anti-condensation requirements, i.e. 5°C.

Where switch rooms are adjacent to instrument marshalling stations or local control rooms, consideration shall be given to utilising the same plant to serve both facilities.

3.15 Uninterruptible Power Supply (UPS) Rooms

Dedicated ventilation and cooling plant shall be designed to limit temperature and to provide the correct air filtration to the UPS manufacturer's requirements. Anti-condensation heating to 5°C shall be catered for and a positive pressure in the room of 25 Pa.

Two 100% capacity plants shall be provided, with automatic changeover facilities. One plant shall operate from the emergency power supply.

3.16 Battery and Invertor Rooms

3.16.1 Battery rooms shall be provided with dedicated mechanical exhaust ventilation systems to remove gaseous vapours and fumes released from the batteries.

Two 100% capacity plants shall be provided, with automatic changeover facilities. One plant shall operate from the emergency power supply.

Extract shall be provided from both high and low level points in the room to give a minimum of 6 air changes per hour.

Failure of the battery room extract system shall inhibit boost charging of the batteries, if either lead/acid or sealed Ni/Cd batteries are used.

The ductwork within the battery room shall be either stainless or galvanised steel with chlorinated paint on the inside and external surfaces of the ductwork system. Supply air shall be provided at low level.

3.16.2 Invertor rooms shall be provided with ventilation, cooling and filtration to protect the equipment and limit the temperature rise due to equipment heat emissions. Anti-condensation heating of 5°C shall be provided.

Two 100% capacity plants shall be provided with automatic changeover facilities. One plant shall operate from the emergency power supply. Alternatively ventilating/cooling air may be provided via a central HVAC plant providing operating times are identical.

Relief air from the inverter room should be transferred into the battery room.

3.17 Dining Rooms

Dining rooms shall be provided with heating, ventilation or air conditioning if this can be justified, for the general comfort of personnel.

The HVAC system shall be independent of central HVAC plant and capable of efficient operation during intermittent usage and variable occupancy loading.

All-air, variable volume HVAC systems are favoured but fan coil systems may be utilised. Small dining rooms may only justify individual air conditioning units of the 'through the wall' type or a constant volume system incorporating partial recirculation of air for heating economy.

All types of system shall provide air for transfer to the kitchen via the service area. The HVAC plant shall comprise a supply plant incorporating a main air filter handling total air and recirculation/discharge air fans. Due attention shall be paid to draught free air distribution and acoustic attenuation of the plant.

Two 50% capacity HVAC units or other suitable sparing arrangements should be provided, appropriate to the application.

3.18 Kitchens

3.18.1 General

Kitchen ventilation cooling systems shall be designed to provide acceptable working conditions for personnel, localise escape of cooking odours and limit the effects of radiant and convected heat produced by the cooking appliances.

Plant sparing shall comply with one of the formations in the Sparing Philosophy (see 2.3).

3.18.2 Extract System



The kitchen extract system should be totally separate, allow no recirculation and maintain the kitchen at a negative pressure relative to other areas in the building. Where full details of kitchen appliances are known the extract air flow rate can be established by reference to Table B2-11 in the CIBSE Guide.

If appliance details are not known, an approximate extract rate in litres/second should be based on number of meals served in one hour multiplied by 10 to 15.

In all cases the extract rate should not be less than 17.5 l/s per m² of floor area, nor less than 20 to 30 air changes per hour.

Separate wash-up, preparation and pastry preparation areas, etc., in larger kitchens should be provided with a minimum of 10 air changes per hour.

Specific attention shall be given to avoid cooling of meals at serveries by excessive air movement.

3.18.3 Extract Hoods

Extract hoods shall be provided above all cooking appliances and equipment. Hoods should normally be of the valance or island type sized for a minimum of 0.35m/s air flow velocity through the hood opening and designed and constructed for easy cleaning.

The materials used for hoods, extract ductwork and lagging shall be non-combustible and maintain the fire rating integrity of any area through which they pass.

Extract hoods shall generally incorporate integral, cleanable grease filters, particularly in conjunction with fish fryers. Extract ductwork systems shall be insulated where necessary to prevent the formation of condensation; have sufficient access doors for adequate internal cleaning and terminate at high level to avoid nuisance caused by cooking smells. Duct connections shall slope towards the hoods to drain condensation.

All kitchen/servery wash up hoods shall have an internal profile giving a slope towards the edges. All hoods shall have an external edge drain gulley around the perimeter. Kitchen extract hoods shall not incorporate air volume control dampers.

Specific attention should be given to fitting individual automatic AFFF fire extinguishing systems within the hood of any larger fish fryer.



3.18.4 Make-up/Replacement Air

Kitchen facilities, not directly adjacent to restaurant/dining areas shall be provided with a dedicated fresh air supply air system to introduce 80% to 85% of air extracted and maintain pressurisation differentials.

Where properly ventilated/air conditioned restaurants adjoin the kitchens they shall provide make-up air at a maximum rate of 7 l/s per head. Any difference in extract and make-up air shall be provided by a separate kitchen supply system. This system shall provide spot cooling for kitchen personnel working at high radiant heat locations. Air transfer grilles sized for 1.0 to 1.5 m/s through the free area should be provided between the restaurant and kitchen where serving hatches are small or likely to be shut for long periods.

Transfer air velocities should not exceed 0.25m/s.

3.19 Mess Rooms

Mess rooms may be intermittently occupied, but they shall be provided with a mechanical extract system for the removal of odours and fumes produced by tobacco smoke, hot beverages and meals, etc.

Make-up air shall be provided from central plant or allowed to infiltrate from surrounding areas.

Mess rooms shall be maintained at a lower pressure than surrounding areas to prevent egress of odours and fumes.

3.20 Stores

Stores shall be heated, ventilated or air conditioned for the protection of the stored product.

This will entail provision of a clean, dry environment, heated or cooled as required, pressurised to prevent the ingress of dust and fumes.

Where products are stored at low temperatures, duty and stand-by unitary or split system refrigeration plant arrangements shall be provided.

Where products are stored at elevated temperatures and large air flow rates are involved, heat recovery systems should be considered.

Supply and extract services may be available from central plant otherwise independent plant will be required, spared in accordance with the Sparing Philosophy (see 2.3).

3.21 Laundry Rooms

Laundry rooms shall be ventilated, cooled or heated for comfort of personnel and for the removal of moisture, lint and other airborne contaminants generated by laundry processes.

Exhaust air from automatic dryers shall be conveyed to atmosphere by arrangement of auto-changeover duty and stand-by extract fans together with an extract ductwork system connected to each dryer. A cold air entry to the extract shall be provided at each dryer outlet so that room air can mix with the hot discharge air before entering the extract system.

Each dryer connection shall incorporate a cleanable wire mesh or synthetic material filter to capture lint and fluff, etc., released during the drying process.

Make-up air to replace that removed at the dryers and to limit temperature rise due to equipment heat gains shall be provided from separate duty and stand-by plant or from central plant serving other areas.

3.22 Toilets and Locker Rooms

Toilets and locker rooms shall be provided with mechanical extract ventilation systems for the removal of body odours, smells and other airborne contaminants.

The systems shall comprise two duty and stand-by automatic changeover extract fans with ductwork systems sized for a minimum extract rate of 10 air changes per hour.

Make-up air shall be provided by associated central plant or by infiltration/migration of air from other areas.

Locker rooms used for wet clothing shall incorporate heated drying rails and tubular heaters adjacent to lockers. The tubular heaters shall be thermostatically controlled and incorporate fault trips.

Air extract points shall be located over each locker.

3.23 Plant Rooms

Plant rooms containing HVAC building services plant or equipment shall be mechanically ventilated to limit temperature rise due to heat gains from the equipment. A small over-pressure of 15 Pa is desirable in the plant room.

Where possible, plant room ventilation should be incorporated as part of the central HVAC plant contained in the plant room. For other cases separate independent systems shall be provided.

3.24 Corridors

Corridors in buildings shall generally be over-pressured relative to rooms by means of air supplied by the central plant. A dedicated pressurisation control damper should be considered for this purpose.

Over-pressuring will assist the escape of personnel in a fire by preventing ingress of smoke or fumes.

4. DESIGN REQUIREMENTS

4.1 General

The design should consider the following issues:-

- Safety
- Operability
- Constructability
- Applicable codes
- Good engineering practice
- Minimum Cost
- Efficient systems operation.
- Suitability for the application.
- Practical and economic maintenance provisions.

The Design Contractor should demonstrate that the selected approach is optimal, by means of appropriate capital and operating cost estimates.



The design of the systems is deemed to include specification and selection of plant and equipment items together with all controls and instrumentation associated with the systems.

The design shall take into account the following influencing factors:-

- | | | | |
|-----|----------------|---|---------------------------|
| (a) | Climate | - | arctic |
| | | - | temperate |
| | | - | arid |
| | | - | tropical |
| | | - | dry bulb temperatures |
| | | - | wet bulb temperatures |
| | | - | rainfall |
| | | - | wind |
| | | - | airborne contaminants |
| (b) | Location | - | country |
| | | - | latitude |
| | | - | altitude |
| | | - | inland |
| | | - | coastal |
| (c) | Exposure | - | sheltered - city/town |
| | | - | exposed - open land |
| (d) | Orientation | - | sun path |
| | | - | prevailing wind direction |
| | | - | prevailing wind speed |
| (e) | Classification | - | non-hazardous |
| | | - | hazardous |
| | | - | proximity to hazard |
| (f) | Safety | - | fire detection |
| | | - | fire protection |
| | | - | fire/smoke control |
| | | - | gas/vapour detection |
| (g) | Usage | - | continuous occupation |
| | | - | intermittently occupied |
| | | - | infrequently occupied |
| | | - | unmanned |
| (h) | Economics | - | type of system |
| | | - | control |
| | | - | energy conservation |

4.2 Responsibilities

The Design Contractor must ensure that his work is fully co-ordinated with all relevant and associated work whether or not all disciplines are engaged under the same contract.

4.3 Safety

4.3.1 General

The HVAC systems shall be designed for inherently safe operation under all normal and emergency conditions.

All systems shall incorporate a smoke control philosophy in their design. Such a system shall principally pressurise corridors and stairways to a level higher than the surrounding areas to prevent smoke ingress and to permit personnel escape.

For smoke removal, areas having mechanical extract systems shall be at a lower pressure than adjacent areas.

Air conditioning or ventilation systems incorporating air recirculation shall, on detection of smoke, automatically close recirculation dampers and fully open the fresh air and extract air dampers to exhaust the smoke to atmosphere.

Where the possibility exists for toxic or ignitable gas to be drawn into ventilation air intakes, gas detectors shall be provided to automatically shut down the system and close isolation dampers.

Fire and gas isolation dampers shall be provided at air inlet and exhaust penetrations and fire dampers wherever fire rated structures are penetrated. In specific applications fire and gas dampers shall be remotely controllable.

Shut-down of designated fans or fire and gas dampers shall be initiated either automatically by the facilities fire and gas detection system prior to extinguishment release, or manually by the operator's personnel by means of Local Fireman's Panels during an incident.

Blast dampers shall be fitted in air inlets and discharge locations of Blast Protected Category 1 Buildings (see [BP Group RP 4-4](#)).

4.3.2 Accessibility



Access shall be provided for satisfactory implementation of plant and equipment maintenance procedures.

Optimum use of space available shall be considered with respect to plant and equipment layout arrangements. Where possible, duplicated components requiring dismantling or withdrawal for maintenance shall make use of the same access space.

4.3.3 Hazardous Areas

Particular attention shall be given to hazardous area classification and the provision of equipment suitable to operate in the designated areas. Reference shall be made to [BP Group RP 12-2](#) for the requirements of electrical equipment for use in classified areas.

To reduce the reliance on normal and emergency electrical supplies, hazardous areas should be naturally ventilated to create an airflow through the areas to provide purging requirements. Locations where gas pockets could form should be reconfigured to eliminate the problem or provided with mechanical ventilation such as a 'jet air' system.

Where natural ventilation is inappropriate, areas shall be mechanically ventilated and/or pressurised preferably by means of a system which optimises air circulation by induction methods.

Air intakes for pressurising or purging the hazardous areas shall be located in non-hazardous areas remote from the hazard source. The positions of chimneys or flues and the prevailing wind direction shall also be considered when determining the location of air intakes.

Specific attention shall be given to locating air discharges where they will not create problems due to an extension of the hazardous area or contamination of air intakes by toxic materials, smells or odours.

Air inlets should be located at least 6.0m from any ventilation exhaust and 8.0m beyond any hazardous area limit.

4.3.4 Non-Hazardous Areas

Segregation of air inlets and exhausts shall be such that cross contamination caused by recirculation is prevented.

Buildings or enclosures in non hazardous areas are not required to be positively pressurised but it is recommended that simple pressurisation be provided as a minimum to prevent the ingress of the external environment, dust and odours.



There is no statutory requirement for pressurisation control of non-hazardous areas although guidance is provided in BS 5720 and the IP Model Code of safe Practice: Electrical.

4.3.5 Pressurisation

4.3.5.1 Pressurisation of rooms or areas via the HVAC system shall be employed to:-

- (a) achieve pressurisation differentials to give the required segregation for area classification.
- (b) prevent infiltration of the external environment and consequent heat gain or loss to the enclosure.
- (c) provide a means of smoke control by pressurising escape routes.
- (d) to minimise the transfer of odours, smells and contaminants from one area to another, e.g. kitchens, galleys, toilets.

4.3.5.2 Two types of pressurisation may be used:-

- (a) Simple - achieved by designing supply and extract air flows to be in excess of one another to obtain the design pressure differentials.
- (b) Fully Controlled - achieved by means of automatic duct mounted pressure control dampers or, fan inlet radial vane dampers, to modulate air flows in response to monitored room pressure conditions compared to a pressure reference point and thereby maintain pressure differentials.

4.4 Design Criteria

4.4.1 External design conditions.

For worldwide applications, reference should be made to Table A2-22 in the CIBSE Guide. The table lists 1% annual exceedance values of external dry bulb and wet bulb temperatures in summer and 2.5% annual exceedance values for dry bulb temperatures in winter.

For UK installations reference shall be made to Table A2-1 in the CIBSE Guide for winter design dry bulb temperatures; summer design dry and wet bulb temperatures shall be extrapolated from Tables A2-5 and A2-6 in the CIBSE Guide.

4.4.2 Internal design conditions

For internal design conditions, reference should be made to Fig A1-2 and Table A1-2 in the CIBSE Guide.

Recommended values for UK installations are listed in Table A1-3 in the CIBSE Guide.

4.4.3 Ventilation rates

Ventilation rates shall be based upon:-

- Occupancy - the minimum fresh air rate required per person in enclosed areas as given by CIBSE Guide.
- Odour control.
- Condensation control
- Hazardous Areas - 12 air changes per hour.
- Non-hazardous Areas - 6 air changes per hour.

The air changes quoted are recognised minima and shall be subject to increase as necessary to offset space heat gains/losses and to provide aspiration air for equipment in relevant areas. If these rates cannot be achieved by natural ventilation (as demonstrated by calculation) or where particular hazards dictate, mechanical ventilation (in whole or in part) shall be provided.

Air change rates shall be based on full space volume without reduction being made for contained equipment.

The requirement for 12 air changes per hour for hazardous areas is derived from 'Adequate Ventilation' in accordance with [API RP 500B](#) Section 2 item 2.2C. However, it should be recognised that the empirical approach cannot fully account for the significant local influences on air flows within any ventilated space. Where stagnant regions are possible it may be necessary to carry out a detailed flow analysis. The design approach should be based on an appropriate standard and the philosophy documented accordingly.

The requirement for 6 air changes per hour for non-hazardous areas is to ensure comfort and safety of personnel and to prevent the ingress of toxic or ignitable gas.

It should be noted that efficient ventilation and purging of a space will only be achieved if the air flow is evenly distributed throughout.

4.5 Air Conditioning System Requirements

4.5.1 General

Air conditioning systems shall be designed to meet:-

- (a) daily and annual variations in outdoor temperature, humidity and solar radiation.
- (b) internal load variations due to movement of people and operation of lighting, machinery and equipment.
- (c) maximum heating and cooling loads and potential load conditions including nights and weekends and providing frost protection if required.
- (d) sensible and latent load ratios that may be different from (and more onerous) than those occurring at maximum load condition.
- (e) provision at all times of adequate ventilation without draughts or stuffiness and with noise and vibration below the established design conditions.

4.5.2 All-Air Systems

All-air systems shall cater for total heating and cooling loads by controlling the supply air condition. The system should incorporate a re-circulation facility where a proportion of the air is extracted and the remainder mixed with fresh incoming air.

All-air systems may employ high or low velocity supply air ductwork distribution systems.

All-air systems may be categorised as follows:-

(a) Constant Volume

Constant volume all-air systems should be used in locations which operate with a reasonably constant load throughout the year. They may be either low or high velocity systems.

Low velocity systems generally include unitary systems with multi-zone units (with hot and cold deck mixing) a particular example.

High velocity systems should employ single or dual duct supply to terminal units; dual duct systems mixing hot & cold air supplies at the correct proportion to provide temperature control as dictated by room or space thermostats.

(b) Variable Volume

Variable volume all-air systems should be used in locations which operate at partial loads for most of the year. Prime energy consumption will be reduced by reducing the supply air volume (and corresponding extract) under low load conditions.

Specific attention shall be given to ensure that satisfactory air distribution, space humidity control and adequate fresh air quantities are provided at all times.

Variable volume all-air systems may incorporate high velocity supply air ductwork arrangements with either single duct or dual duct terminal units. The diffuser from each variable volume unit serving a perimeter zone shall be sited at an optimum 500 mm from the window. The maximum distance shall be 1000 mm subject to review with the diffuser designer and the supplier.

(c) Air-Water Systems

Air-water systems should comprise a central plant providing all necessary ventilation air and part of the total conditioning load with main and final control provided by water coil terminals (either fan coil or induction units) located within the conditioned space.

Two, three or four pipe water circulating systems are available, depending on the degree of control required.

With two pipe systems, single flow and return pipes should circulate hot or chilled water as required to provide heating or cooling on a seasonal, manual change over basis.

Three pipe systems should allow for separate supply of chilled and hot water with common return.

Four pipe systems should have separate hot and chilled water supply and return arrangements.

Fan coil units should be located against outside walls; space temperature control shall be achieved by regulating fan speed

(manual control) or by automatic control of water flow and temperature.

Fan coil units may be provided with direct fresh air connection or with ducted conditioned fresh air supply combined with mechanical extract.

Induction units rely on high velocity primary air stream forced through jet nozzles within the unit to induce room air through the unit and over the heating or cooling coils. Capacity control of induction units shall be achieved via water flow regulation or air by-pass arrangements.

High velocity supply air system design allows smaller size ductwork but requires greater fan power.

4.6 Operation and Control

Elaborate systems involving multiple control/instrument interfaces shall be avoided.

Control equipment and accessories should be supplied to meet the degree of accuracy appropriate to the application.

Specific attention should be given to the provision of centralised monitoring and control to achieve optimum operation.

Control equipment and components should be capable of controlled response to load variations during part load conditions, in addition to maximum and minimum load conditions.

Typical schematic control diagrams may be found in Appendices F.1, F.2 and F.3 - Supplementary Commentary.

4.7 Emergency Operation

4.7.1 General

HVAC systems may be required to operate during emergency situations to protect vital equipment or assist in means of escape provided it is safe to do so.

4.7.2 Hazardous Areas

HVAC equipment designed to operate in hazardous areas shall continue to operate in an emergency under operator control following orderly system shut-down. This will require the operator to override the shut-down and restart the system if it is safe to do so and for the system to operate on full recirculation, air intake and discharge dampers remaining closed until re-set via the safety shut-down system.

4.7.3 Computer Suites

Split air conditioning systems provided for computer suites shall continue to operate in the event of failure of the main plant to limit the rate of temperature rise within the suite.

4.7.4 Smoke Control

Smoke control within buildings shall be achieved by operating specific fans and dampers following an emergency, to create local areas of pressurisation. The operation of these fans and dampers shall be from a remote location, i.e. from the Local Fireman's panel.

The local areas of pressurisation are necessary to allow means of smoke-free escape of personnel.

4.8 Calculations

Calculations shall be produced to support all system and equipment selection and sizing.

These calculations shall include:

- Building fabric heat exchange (gains/losses).
- Internal heat gains.
- Duct and pipework flowrates, pressure drops and sizing.
- Equipment electrical power consumption and motor kW.
- Equipment utilities consumption: air, water, steam.
- Weight estimate for major equipment, and bulk materials.

A comprehensive survey of the internal load shall be made. A list of occupancy, lighting, instruments, machinery, rectifiers and other equipment releasing heat shall be prepared including use factor, load factor, power input, calculated heat release, location arrangement and other specific requirements.

Infiltration gains or losses shall not be included when the areas are internally pressurised, unless the infiltration pressure exceeds the controlled pressure.

Natural ventilation calculations should consider both wind pressure differentials and stack effect created by thermal gradients.

The natural ventilation wind effect component shall be calculated to provide the minimum air change requirements based on a wind speed of 0.5 m/s and the room or enclosure should have louvres or openings on at least two opposite or adjacent faces.

4.9 Energy Conservation

Energy conserving or recuperative features shall be adopted wherever these can be justified by an acceptable pay-back period against capital expenditure.

To assist the effectiveness of these measures, the buildings should be constructed in accordance with the recommendations of the CIBSE Building Energy Code. Consideration should be given to the use of solar reflecting glass, double or triple glazing, blinds or other specific methods which can be justified.

The maximum use of outside air for cooling purposes should be considered particularly where internal upper temperature limits are above maximum external ambient temperature.

In locations with extreme external ambient conditions of temperature and humidity, outside air quantity should be minimised in order to reduce heating, cooling and dehumidification loads.

4.10 Noise and Vibration

4.10.1 General

All machinery shall be isolated from foundations and fixed pipework and ductwork by means of vibration isolators and flexible pipework/ductwork connectors, including sound proofing and ductwork silencers if applicable.

The effect of noise levels on all buildings and from equipment housed in buildings shall be investigated and taken into account during detail design.

Plant shall be selected and systems so designed that noise and vibration levels quoted in 4.11.2 below are not exceeded.

In the U.K. the requirements of the Noise at Work Regulations 1989 will be applicable.

The aim of these measures is to limit vibration transmission and achieve acceptable noise levels in adjacent occupied rooms and spaces.

* 4.10.2 Noise

In order to provide acceptable living or working environments, sound levels due to the systems shall comply with the recommended design criteria given in Table A1-10 and Section B12 in the CIBSE Guide. Specific attention shall be given to the selection of fans (including those for condensers and cooling towers) motors, fan coil units, terminal units, grilles, diffusers, the internal finish, arrangement and air flow velocities of distribution ductwork in order to achieve the required noise levels.

Acoustic louvering or screening may be required around air-cooled condensers or cooling towers to reduce noise transmission to surroundings.

Noise level information for the above equipment, based on octave band analysis data together with the reference level and testing technique shall be provided for client approval.

Sound attenuators shall be sized and/or acoustic lining provided in the ductwork as required to achieve design noise levels.

Where necessary, duct sizes shall be increased over those shown on drawings as acoustically lined, so as to maintain the same cross sectional area.

Acoustic insulation shall also be applied to ductwork externally to prevent noise transfer where an intrusive noise from any source is unacceptable and where duct mounted sound attenuators will not suffice.

4.10.3 Vibration

Rotating assemblies shall be balanced in accordance with [ISO 1940](#).

For fans with driver ratings up to 15 kW, vibration levels measured in three planes at the bearing housings shall not exceed 1.8 mm/s RMS. Between 15 and 75 kW vibration levels shall not exceed 2.8 mm/s RMS.

All air conditioning units, ventilation fans, pumps, compressors and water chilling units shall be mounted on anti-vibration mountings of the metal to rubber bonded in shear type so that all units are mechanically isolated from the main structure.

Where a large amplitude is required, spring isolators incorporating rebound damping shall be provided.

Anti-vibration mountings, which should have means of levelling, shall be selected for the particular application of machinery and location, providing not less than 95% isolation from the disturbing force.



5. EQUIPMENT

5.1 General

Equipment shall be selected with due consideration to the location of the installation (coastal sites being far more severe on the life expectancy of plant than inland installations) and the particular application.

The equipment supplied shall be of robust construction of a proven design suitable for the specified hours of operation.

All equipment shall be suitable for its intended purpose and provide safe use under all known operating conditions including overload if anticipated.

Protective devices shall be incorporated where necessary for personnel safety.

5.2 Ductwork and Fittings

5.2.1 General

Ductwork installations shall be designed to convey fresh or conditioned supply air together with re-circulated exhaust air as required throughout the buildings.

Specialist ductwork systems may be required for exhausting and/or conveying abrasive or toxic materials. In these cases special references shall be made to CIBSE Guides.

The ductwork arrangements may be either centralised or local with high or low velocity supply air systems and low velocity recirculation and exhaust systems.

The ductwork systems shall be airtight and of good aerodynamic design so as to minimise air turbulence, noise generation and friction losses. They shall be adequately braced and stiffened to prevent drumming and shall be suitable for direct connection to equipment such as fans, dampers, heaters, coolers, air terminals and grilles, etc.

Ductwork and associated fittings comprise straight sections, hoods, bends, tees, branches, hangers and supports, louvres, manual and automatic dampers, access and cleaning holes.

Specific attention shall be given to the provision and location of an adequate number of balancing dampers to ensure ease of flow regulation.

Final duct connections to air terminals or diffusers may be made with flexible ductwork of appropriate fire rating to satisfy local or national regulations.

All low and medium velocity ductwork shall be leak tested in accordance with DW 142 Table 1 and air leakage class B and EUROVENT 2/2.

5.2.2 Design Principles

There are two main categories of ductwork systems.

- | | | | |
|-----|---------------------------------|---|--|
| (a) | Low Velocity,
Low Pressure | - | with duct velocities less than 10 m/s and static pressures less than 0.5 kPa for distribution systems and 1.0 kPa for plant connections. |
| (b) | High Velocity,
High Pressure | - | with duct velocities between 10.00 and 40.00 m/s, positive static pressures between 0.5 kPa and 2.5 kPa; negative static pressures up to 1.5 kPa |

5.2.3 Materials and Construction

Materials and construction shall, as a minimum, conform throughout to the recommendations contained in the HVCA ductwork specification DW 142.

Ductwork should be manufactured from galvanised mild steel sheet, although plastic, glass reinforced plastic, stainless steel or masonry may be proposed for appropriate duties. Materials should be incombustible; plastic ductwork shall be provided with adequate fire protection insulation, etc., to ensure the integrity of the system.

External ductwork shall be of a high quality, heavy gauge, robust construction and shall be protected from the elements as appropriate. For example, external steel ductwork shall have a minimum thickness of 3 mm, shall be fully welded construction and either galvanised after manufacture or painted.

Where masonry airways are proposed the interior surface should be fire resistant, smooth, airtight and treated against erosion.

Kitchen extract hoods shall be of brushed finish stainless steel and shall be provided with adequate clean-out openings to facilitate full access for cleaning of the ductwork. The arrangement shall include cleanable grease filters and an automatic dry powder or inert gas fire protection system. Integral vapour-proof lighting panels shall be provided inside the hood.

Suitable insulating gaskets, sleeves and washers shall be provided where dissimilar materials may be in contact in order to prevent galvanic corrosion.

Where ductwork penetrates vertical or horizontal walls or floors, the ductwork penetration shall be arranged such that undue load is not carried on the structure, that leakage around the duct is minimal and the fire integrity of the wall or floor is not impaired.

The space between the ductwork and penetrations shall be caulked with fire resistant packing as a means of fire stopping around the duct.

5.3 Piping Systems

5.3.1 General

Layout of HVAC piping systems shall be considered in relation to the building or enclosure structure and due consideration and allowance shall be made for:-

- co-ordination with architectural & structural requirements
- co-ordination with other services
- simplicity of the installation and constructability
- access for commissioning, operation & maintenance
- access and facilities for testing.

5.3.2 Water Piping

Water piping for heating and cooling systems may be steel or copper with screwed, flanged or welded joints, in accordance with [BP Group GS 142-6](#).

The piping arrangement should ensure a good distribution of water to the various heaters or coolers within the HVAC system at all conditions of load.

An economic balance between pipe sizes and pumping power is required.

Note that it is advantageous to design the systems with the maximum practical temperature differential to give a minimum flow rate.

Water velocity shall not exceed 4.0 m/s.

Water velocities in excess of 4.0 m/s must be avoided in order to limit system noise and erosion of the pipework.

Location of expansion joints should be considered in relation to branches which may accommodate only small movements. The maximum load applied to pumps or other equipment in the line from the piping shall not exceed the equipment vendor's specified limits.

Provision must be made for venting at the system high points and for draining the system low points.

Water volume expansion, due to change in water temperature, should be catered for by provision of a suitable expansion device, either an open tank arrangement located at the highest point in the system, to maintain a positive pressure in the system, or a pressurised (by inert gas) closed tank arrangement installed at a lower level.

5.3.3 Steam Piping

Steam supply and condensate return piping for heating systems may be steel or copper with flanged or welded joints in accordance with Appendix A of [BP Group GS 142-6](#).

The steam supply piping shall be uniformly graded in the direction of steam flow to allow complete drainage of the system when not in operation; free from pockets where condensate can collect (except those provided for collection and drainage) and shall be capable of distributing steam at full design and partial loads.

Condensate lines shall be graded to drain by gravity to a condensate receiver, for lifting to the condensate return line, or to waste sewer.

For optimum performance and to evacuate non-condensable gases (CO₂/Air) individual steam traps shall be provided for each separate heat emitter.

The steam traps should be sized to discharge the maximum rate of condensate and should perform effectively over the entire operating



range to minimise the escape of live steam, or backing up of condensate.

Typical steam trapping arrangements are illustrated in BP Standard Drawing S-1240 (7 sheets).

5.3.4 Refrigerant Piping

Refrigerant piping shall be of seamless copper tube with capillary fittings for smaller sizes or steel for larger sizes.

Refrigerant piping systems should be designed for minimum pressure drop and gas velocities to prevent oil entrainment.

Due consideration should be given to the following:-

- *maintaining a clean, dry system.*
- *ensuring correct distribution of refrigerant in evaporators.*
- *ensuring entrained lubricating oil is always conveyed back to the compressor without formation of accumulation and slug flow in the suction line.*
- *preventing liquid refrigerant draining into or condensing in the compressor during shut down, and from entering the compressor during operation.*
- *avoiding excess suction gas superheat at the compressor inlet.*

Refrigerant lines shall be clear of all foreign matter such as flux and welding dross, and evacuated before charging with refrigerant, using a vacuum pump to remove moisture and condensable gas in accordance with CIBSE Commissioning Code R.

Bends, springs and sets up to and including 42mm diameter may be made in situ where standard fittings cannot be used or where this method will give a neater appearance. Pulled bends or offsets which show flattening, rippling or constriction of the bore will not be accepted.

Long horizontal lines should be inclined to assist flow. Fittings in an appropriate inert material should be provided between abutting sections of copper and steel piping.

5.4 Fans

5.4.1 General

Selection shall be based on the most suitable combination of size, arrangement, type and class of construction to meet the required duty



while providing stable operation at an acceptable noise level and efficiency.

Motors, drives, starters and overloads shall be compatible with the required fan.

A suitable margin (circa 10%) over the estimated design load should be allowed for rating of motors, starters and cabling.

Fans should be both statically and dynamically balanced before leaving the supplier's works.

Belt driven fans shall have a minimum of 2 belts provided. Belt guards shall be provided and include access for motor speed, fan speed and belt tension check without removal of belt guard.

Fans for use in hazardous areas shall be suitable for the application, having anti-sparking protection; materials used shall be incombustible (aluminium shall not be used); non-sparking rubbing strips shall be incorporated where moving parts may come in contact, drive belts shall be anti-static; sufficient earthing bosses shall be incorporated to allow proper hook-up of the fan assembly to the facility earthing system.

The following factors should be appraised when selecting fans:-

- *air flow rate*
- *system resistance*
- *entering air condition: temperature, humidity, density, contaminants i.e. dirt, fumes, gases, etc.*
- *barometric pressure/altitude of location*
- *application (comfort, quiet, industrial)*
- *space available for fan motor and drive*
- *permissible weight and structural loading*
- *installation configuration, position of inlets and outlets and direction of discharge*
- *type of drive and arrangement; facility for drive type adjustment; type of bearings and greasing arrangement; guards and speed control*
- *fan accessories such as casing access doors, drain plugs, vibration isolators, flexible connections and flanged inlet and outlet connections*
- *special features : protective paint and finishes, split casing (large centrifugals)*

5.4.2 Axial Flow Fans

Axial flow fans shall comprise an impeller with aerofoil section blades mounted on a hub located in a cylindrical casing. The fans should be compact and suitable for mounting in any location in the ductwork systems. They may be either direct drive or belt driven. The supplier

shall be advised whether the fans are to be mounted vertically or horizontally to ensure that correct bearings are incorporated.

These fans will generally be used for low pressure applications, where the system pressure is not subject to fluctuation.

Increased pressure may be generated by the addition of guide vanes or by arranging contra-rotating fans in series.

5.4.3 Centrifugal Fans

Centrifugal fans shall consist of an impellor mounted in a volute casing such that air entering the casing axially is discharged radially. The fans may be either direct drive or belt driven.

Centrifugal fans may be:-

- (a) Forward Curved: the impeller shall comprise multiple short forward curved blades operating at slow speed to generate low pressures at medium efficiency (50-60%). These fans are suitable for all low and medium pressure duties in stable, non-arduous ventilation applications.

These fans will have an inherent overloading characteristic, i.e. at constant speed a reduction in pressure requirement will give increased flow rate and increased power requirement.

- (b) Paddle Bladed: the impeller shall have a number of radial blades mounted on a 'spider' or back plate. These fans are suitable for conveying air with a high dust burden or abrasive particles generally applied to industrial extract systems.
- (c) Backward Inclined: the impeller shall comprise a number of deep, backward inclined blades either straight or curved. These fans will operate in the higher efficiency ranges of 70 - 75%, generate medium to high pressures (1000 to 3500 Pa) and have a non-overloading characteristic.
- (d) Backward Curved Aerofoil: shall have similar operating characteristics to backward inclined type but aerofoil section blades will result in higher efficiency (80 - 85%) operation. These fans will generally be applied in systems requiring high pressure levels, i.e. large high velocity systems.

5.4.4 Propeller Fans



Propeller fans shall be designed to operate against low resistance in free air conditions. The fans shall comprise two or more blades of constant thickness fixed to a centre boss, arranged for diaphragm mounting. The fans shall have very high volumetric capacity at free air delivery with very low efficiency (less than 40%). These will generally be used for simple supply or extract systems (without ductwork) and in small cooling towers and air cooled condensers.

5.4.5 Tangential Fans

Tangential fans shall comprise a forward curved multiblade centrifugal type impeller but with greatly increased blade length and with the normal air entry blanked off. The fans will generate a relatively high discharge velocity suitable for use in fan coil units and room air conditioners, etc.

5.4.6 Mixed Flow Inline Fans

Mixed flow fans shall incorporate both axial and radial air flow components by means of a shrouded impeller with aerofoil section blades on a conical hub. Stator guide vanes shall be provided downstream to remove swirl generated by air flow through the impeller.

The fans shall operate at high efficiency (70 - 75%) and at higher static pressures than equally sized axial flow fans.

The minimum operational hours of the motor bearings shall be 30,000.

They are capable of being installed in any position within ductwork systems and will frequently be used in systems requiring large air flows at high pressure, subject to fluctuating external pressure on the system.

The supplier shall be informed if the unit is to be used in the vertical plane.

5.5 Filters

5.5.1 General

Filters shall be provided at the air intakes of mechanical ventilation and air conditioning systems to reduce the amount of air borne silt, dust and contaminants from entering the building in addition to the removal of odours, vapours, gases, etc., as necessary.

All filters shall have pressure differential sensors connected across each filter. Specific attention shall be given on larger systems for automatic alarm at the HVAC control panel.

Design shall be in accordance with [BS EN 779:1993](#) (EUROVENT 4/5) and from which various factors and definitions are utilised below.

5.5.2 Selection

The following factors shall be appraised when selecting filters.

- design air flow rate
- air velocity across the filter face
- resistance (pressure drop) for clean and dirty filter conditions
- filter efficiency
- upstream and downstream concentrations of dust particles
- dust holding capacity : the mass of dust the filter can retain while maintaining air flow during a rise in pressure drop from initial clean resistance to twice that amount.
- possible fire hazards.
- size of plant or installation.
- economic considerations of capital cost, replacement material costs, cleaning operations and labour involved.

Filter selection should be determined for a particular application using data provided in Section B3 and Figure B3.58 in the CIBSE Guide.

5.5.3 Filter Types

Filters may be dry media panel type or viscous impingement type and either replacement/throwaway type or automatic arrangement.

Dry panel type filters will usually be employed on small systems of up to 5 m³/s total flow rate. Constructed in various sizes of panel to operate at face velocities of 1.0 m/s up to 1.25 m/s, they may be arranged for front, side or rear withdrawal.

Rear withdrawal dry panel type filters are used only when a second stage filter is provided.

5.5.3.1 Permanent Dry Type

The filter media may be fabric, processed plastics or brush type, with efficiency up to 95% and with medium to high dust holding capacity. The filters shall be cleanable by either washing, compressed air or vacuum cleaning. They may be used as either pre-filters or main filters.

5.5.3.2 Dry Replaceable Media Type

These may be used as main filters with high efficiency 95% to 99% and high dust holding capacity. The filter media shall be wadding or fabric carried on metal frames arranged in pleated 'W' or bag form to present a large filter surface area.

Filter media shall normally be changed/replaced at 1.5 - 2.0 times the initial pressure drop.

5.5.3.3 Throwaway Type

May be used on smaller plants where servicing requirements of permanent types would be uneconomic.

Efficiency may be up to 90%. Media materials may be fabric, plastics, glass or metal fibre mounted in wood, metal or cardboard frames.

5.5.3.4 Viscous Impingement Type

These filters may be all metal construction between 50 mm and 100 mm thick and have efficiency of up to 90%. They should have high dust holding capacity with little increase in pressure drop.

The filters should be serviced by washing and re-oiling and will be primarily used for industrial or engine air intakes.



5.5.3.5 Automatic Air Filters

Automatic air filters should be used on large systems where space permits and where they have economic advantages over panel types. They may be selected for air flows ranging from 0.5 m³/s with face velocities between 2.00 and 2.75 m/s. Higher velocities shall be avoided as this results in increased pressure drop and possibility of carry over of filter media or wetting oil.

Automatic air filters are packaged units; generally they comprise a large open framework over which continuous lengths of motor driven filter media is gradually advanced such that as the media becomes loaded with dust it is continuously replaced with clean media.

5.5.3.5.1 Automatic Dry Type

Available in various grades of filter media (glass, acrylic or similar fibre) with efficiencies of 80% to 85% - depending on media density. Media advancement should generally be via pressure differential switch arranged to wind over the two spools in V, W or S patterns using guides or rollers to reduce overall size.

These filters generally comprise one spool of dry fabric media which is automatically drawn across the air stream and wound onto a second spool.

5.5.3.5.2 Automatic Viscous Type

Automatic viscous impingement air filters should be used in environments subject to heavy concentrations of dust.

The filters may be rotary screen, rotary panel or constantly cleaned fixed element type, with efficiencies of 80% to 85%. They shall normally be time switch controlled to maintain constant operating resistance of 50 Pa to 125 Pa according to type. Removal of dust sludge from the oil trough shall generally be manual, automatic removal is not normally employed.

They comprise a continuously rotating curtain passing through a bath or trough of oil which acts to remove the dust loading and renew the viscous coating.

5.5.3.6 Electrostatic Air Cleaners

These filters are capable of removing large quantities of dust especially in the smaller particle range. They should be used with pre-filters (to remove large particles and ensure even air flow over the face area) and after filters (to collect large agglomerates breaking free from collection plates).

As these filters operate at high voltage, suitable interlocks shall be provided to ensure 'power off' when maintenance access is required. A supply of hot water with detergent solution is also required for washing down. This is normally an automatic function integrated into the control sequence.

Electrostatic air cleaners are two stage packaged units. The first stage comprises a series of fine wires that imparts the dust particles with a positive electrical charge; the second stage, consisting of a series of parallel plate generally coated with a water soluble viscous solution is charged negative or alternatively negative and positive. The voltage gradient thus created causes the positively charged dust particles to be deposited on the negatively charged plates.

5.5.3.7 Carbon Pack

These filters may be used to remove odours, fumes, vapours and gases, etc., in order to protect personnel or sensitive materials/equipment. The filters should operate with a low face velocity, less than 1.75 m/s. Provision of an efficient pre-filter is essential to avoid rapid 'clogging' of the carbon media.

The carbon media may be either 'activated' or 'catalytic' and may be either 'throw-away' or suitable for regeneration by the manufacturer.

Carbon pack filters are generally pre-fabricated fully assembled packaged units comprising shelves of carbon packed panels or trays contained within a steel casing.

The carbon media should be continuously monitored to ensure correct performance and should be replaced when performance is no longer adequate.

5.5.3.8 Absolute Filters

High efficiency particulate air (HEPA) or absolute filters with efficiencies of 99% to 99.995% in accordance with [BS 3928](#) sodium flame test shall be provided for medical or clean room applications.

The media should be suitable for high humidities, high temperatures or chemically corrosive atmospheres, or both. The filters should always be used in conjunction with pre-filters.

For optimum performance the filters should operate with low face velocities (less than 1.5 m/s) and with laminar air flow. The panel arrangements shall be properly sealed in place and tested in situ to detect any leakage prior to commissioning.

These filters comprise panels of treated or glass paper media in honeycomb formations contained in mild steel or wooden casings.

5.5.3.9 Sand Filters

Sand/Dust filters shall be the packaged inertial separation type comprising assemblies of prefabricated vee-pockets all contained within a sheet metal casing with flanged inlet and outlet suitable for duct-work connections.

The assembly shall be inherently self cleaning or shall be provided with an automatic compressed air blow-through cleaning system. Deposited sand and dust shall be collected into chutes or hoppers for transportation elsewhere.

The air intake connection shall be provided with insect screen and weather louvres as required.

5.5.3.10 Grease Filters

Grease filters shall be provided in kitchen extract hoods particularly associated with fish and fat fryers. The filters shall be designed to provide ample cooling surface area to cool cooking vapours sufficiently for the grease vapour to condense onto the filter media.

Grease filters shall comprise all-metal cells, electro-galvanised, with woven wire media formed into pyramid pockets contained within metal panel frames fitted with handles for ease of removal. The panels may also be of stainless steel having impingement vanes.

The filters shall be cleanable by immersion in hot water/detergent solution.

5.6 Filter Coalescers

Filter coalescers should be utilised in coastal regions where fog, sea mist or driving rain frequently occur.

Filter coalescers shall comprise an arrangement of first-stage coalescer panels and second-stage inertial separation contained within a stainless

steel casing suitably flanged for ductwork mounting, complete with drain trap connection.

The first-stage coalescer shall comprise panels of synthetic material pads contained in stainless steel frames arranged for side or front access withdrawal; the second-stage inertial separator shall comprise a bank of stainless steel vanes providing at least three changes in air flow direction.

Filtration efficiency shall achieve removal of salt particles to a concentration of 0.05 p.p.m of salt in air by weight under all weather conditions.

5.7 Air Heater Batteries

5.7.1 General

Air heater batteries are defined as duct mounted appliances for warming air. For optimum performance they require uniform face velocity, 3.5 m/s for gilled tube type, and 4.0 m/s for plain finned type.

Heater batteries may utilise hot water, steam or electricity as the heating medium, based on an economic assessment relative to the services available.

The heater batteries shall generally comprise one or more (but not usually more than five) rows of finned tubes or elements connected to headers and mounted within a sheet metal casing having flanged ends. The tubes or elements may be horizontal or vertical, but always horizontal for serpentine coils and always vertical for steam heated batteries. The arrangements should offer minimum resistance to air flow.

Heaters may be sectionalised to suit control, manufacturing or installation requirements.

Pre-heater coils located before air filters should be either plain tube or have wide spaced fins for easy cleaning.

5.7.2 Selection Factors

Factors to be appraised when selecting heater batteries shall be as follows:-

- design air flowrate

- entering air conditions (dry bulb temperature and density), air quality (dirty, corrosive, or hazardous atmospheres), requirement to operate in freezing temperatures.
- required leaving air dry bulb temperature
- air side face velocity and resistance
- heating medium
- steam and hot water
 - entering temperatures and pressures and allowable differentials.
 - size, type and location of connections and circuiting arrangements.
 - provision for air venting and drainage and access for tube cleaning.
- electricity
 - voltage, phases and maximum element temperature.
 - terminal box enclosure rating.
- construction/materials for tubes, fins, casing, number of rows and arrangement, type of extended surface and spacing
- ductwork system air pressure at point of heater installation, air leakage rate through casing.

5.7.3 Hot Water Coils

Hot water coils designed for comfort heating systems usually require no more than one or two rows of tubes in the direction of air flow to produce the required heat capacity. Resistance to hot water flow in low pressure installations through the coils should not exceed 4 kPa. Other factors such as the need to balance circuits will govern the resistance in higher pressure systems. Sufficient hot water flow and return connections should be provided to ensure even distribution of heating medium.

Flow connections should be at the lowest point of the heater with the return connection at the highest point to aid venting.

Coils may be arranged for parallel or contra-flow configurations. Contra-flow (i.e. hottest water meeting the leaving air) is preferred for multi-row coils as this provides the highest possible mean temperature difference.

5.7.4 Steam Heated Coils

Steam heated coils require rapid elimination of air, condensate and other non-condensables together with uniform distribution of steam to the individual tubes for optimum performance.



It is essential that condensate is removed from the coil as soon as it is formed in order to avoid water logging. If the heaters are required to operate under light load then sectionalisation of the controls should be considered.

With entering air temperatures at 0°C or less, a frost valve should be incorporated to pass a continuous warming flow of steam through the coil.

In extreme arctic applications non-freeze 'tube within a tube' type steam coils may be considered.

Adequate means of venting the steam space must be provided.

The steam condition entering the heater should be dry but not superheated.

5.7.5 Electric Air Heaters

Electric air heaters should have the electrical load balanced across the 3 phases of the electric supply.

To provide automatic temperature control the heater should be divided into sections; each section complete with its own bus bars and connections and means of electrical isolation such that individual sections may be capable of withdrawal for maintenance/repair.

All heaters shall be electrically interlocked with fan motors such that heaters will be switched off when fans are stopped or air flow has dropped below a safe level. Manual reset element high temperature trips shall be provided as a safety feature. The manual reset button shall be located on the external face of the heater.

The surface temperature of the heater elements shall be limited to a maximum of 150°C under any condition. Where applicable, the heaters shall be certified for use in gaseous atmospheres.

Electric elements shall be sheathed black heat type incorporating a 80/20 nickel chrome resistance wire welded to terminal pins and encased in an alloy 800 tube.

5.8 Direct Fired Heaters

5.8.1 General



These heaters should be designed to be free standing or duct mounted and suitable for large open area industrial type complexes. The heat exchanger element shall normally be fully welded using aluminized or stainless steel or similar materials to form a clam shell or cylindrical tube and drum exchanger.

The heat exchanger should create minimum resistance to airflow and provide efficient transfer of heat with minimum noise generation.

5.8.2 Selection

Factors to be appraised when selecting direct fired heaters shall be as follows:-

- air flow to be handled
- entering air conditions
- leaving air temperature
- allowable air side resistance
- unit is complete with all necessary safety controls
- location of flue outlet is suitable for unobstructed venting to atmosphere and not subject to wind back pressure
- access provided for inspection and cleaning of pilot and main burners
- sight glasses provided for burner observation
- adequate supply of combustion air to ensure maximum efficiency

5.8.3 Gas Fired

Gas fired direct heaters shall be provided with either an atmospheric type burner or automatic forced combustion type and should be complete with all necessary controls for pre-purging, gas ignition, operation and safety.

- atmospheric burners shall have flame failure devices, solenoid control valves, pilot and ignition controls and (possibly) gas governor.
- automatic forced combustion burners shall comply with appropriate international/national standards.

A manually reset high temperature cut-out shall be provided together with a pressure or flow switch interlock to prevent heater operation in the event of no air flow through the heater, i.e. fan failure.



Flues for atmospheric type burners shall be provided with draught diverters. Automatic burners shall be fitted with either a direct flue connection or with a stabilizer within the flue system.

Flueless gas fired heaters should be used as make-up air heaters and will usually be contained within a packaged unit comprising inlet louvres, filter bank, burner and baffle arrangement and supply air fan. Their use should be limited to large open areas with little or no personnel occupancy, and generally for drying out purposes in new or refurbished buildings.

All units shall be tested and approved by an appropriate national authority.

Note that appliances in excess of 44 kW are not permitted in the UK by the Building Regulations.

5.8.4

Oil Fired

Oil fired heater burners shall be either vapourizing type (for low output equipment) or the pressure jet type, and should be complete with timing controls and safety cut-out devices for ignition failure and main flame failure.

The units shall be provided with high temperature cut-out protection and a safety cut-out for reduced air flow or fan failure, by means of a pressure switch or air-flow switch.

Products of combustion shall be removed via flues either directly or via a flue stabilizer if required.

Flues shall take the shortest and least tortuous route to atmosphere and shall be designed in accordance with Section B13 in the CIBSE Guide.

Oil flow to the burner should be regulated thermostatically to control the leaving air temperature in response to varying conditions.

5.9 Air Cooling Coils

5.9.1 General

Cooling coils shall comprise a number of rows of finned tubes connected to headers and mounted in a sheet steel casing having flanged ends suitable for mounting in ductwork systems or forming part of a packaged unit. Tubes should be either (a) solid drawn copper, expanded into aluminium fins finished with a vinyl coating or (b) copper tubes with copper fins and copper headers, and the whole assembly should be electro-tinned after manufacture. Type (b) shall be used always on coastal installations or installations where the atmosphere is likely to be corrosive. Headers shall be sized to evenly distribute water.

The coils should be provided with condensate drain trays fitted at intervals not exceeding 900 mm and arranged to drain into a sump. In general, cooling coil face velocities shall be in the range of 1.5 to 2 m/s or as required to prevent moisture carry-over. To prevent moisture carry-over, downstream eliminator plates shall be provided if coil face velocities of 2.4 m/s and greater are selected.

Return bends and headers should be housed within removable covers allowing space for insulation and vapour sealing.

The cooling media connections shall be arranged for contra-flow such that the leaving air flows over the coldest coil surface.

5.9.2 Chilled Water Coils

The cooling medium should be chilled water, glycol mixture or (possibly) chilled brine. Where brine is used all construction and welding/brazing materials shall be compatible and fluid velocity in tubes limited in accordance with [BS 5141](#) to avoid erosion in tubes and bends.

Coil leaving air temperatures shall be controlled by modulating the flow of water through the coil.

5.9.3 Refrigerant, Direct Expansion Cooling Coils

With direct expansion refrigerant air cooling coils, specific attention shall be given to control because of the interaction with the refrigeration system and the limiting rangeability of such systems.

To achieve a wide control range the cooling coils should be divided into two or more sections each with its own thermostatic expansion valve,

solenoid shut-off valve and suction line. The sections may be arranged one on top of the other in an interlaced split across the full face or in-line horizontally one behind the other. For increased degree of control each section may be fed by individual compressors and condensing units, each section performing an equal share of the duty to avoid frosting caused by unequal evaporating temperatures.

5.10 Humidifiers

5.10.1 General

Humidifiers designed as packaged equipment for incorporation into the HVAC ductwork distribution should also have controls integrated with the HVAC system to provide humidification in the conditioned space as required to maintain design conditions.

Volt free contacts shall be provided on the humidifier local panel for controls interfacing.

The recommended type of humidifier is the steam generation type comprising electrode boilers, control systems and sterile steam distribution sparge or nozzles forming a packaged unit.

Water supplies should be fitted with an approved type of back flow preventor or combined check and anti-vacuum valve.

Other types of humidifiers are available; however, these are not recommended, to avoid the health risks sometimes attributed to certain types of units which circulate water during the atomising process.

5.11 Air Handling Units

5.11.1 General

Air handling units for buildings and enclosures shall be factory assembled skid mounted packaged units comprising filters, heating and cooling coils, humidifiers, fans, motors and drives, all contained within a single compartmented enclosure.

The packaged units shall be complete with all internal wiring, piping and controls ready for a simple hook-up to building services and utilities such as ductwork, power, water and drainage.

Casings shall be double skinned and encapsulate a thermal and acoustic insulating membrane as specified.

Discharge ductwork connections may be high or low velocity as appropriate.

The enclosure shall be equipped with hinged doors to provide access to the equipment components for operation, maintenance and repairs.

Spacer sections shall be incorporated to facilitate inspection and mounting of control detectors and instrumentation.

Bulkhead lights shall be provided in fan and mixing box sections of all air handling units. The bulkhead lights shall be operated from outside the unit assembly.

Air handling units shall be suitable for either external or internal location as specified, and shall be complete with necessary protective coatings and weather protection as required.

5.11.2 Draw Through Units

Draw through air handling units shall be arranged such that all the unit equipment components (filters, heating and cooling coils etc.) are located on the suction side of the supply fan. In this arrangement the supply air leaving temperature from the cooling coil has to be sufficiently reduced to allow for the supply fan and motor heat gains.

5.11.3 Blow Through Units

With this arrangement the cooling coil shall be positioned on the discharge side of the supply fan.

This will ensure that fan and motor heat gains are absorbed by the cooling coil, and the lowest air leaving temperature can be obtained from the cooling coil. Thus, the minimum mass flow of cold air to the conditioned area will be required for cooling purposes.

Dual duct air conditioning systems shall incorporate blow through air handling units.

5.11.4 Multi-Zone Units

Multi-zone air handling units shall be specifically designed to satisfy particular multi-zone building arrangements.

The units shall include heating and cooling coils positioned one above the other on the discharge side of the supply fan; the coils should be provided with a range of automatic dampers across the face arranged



such that as each hot duct damper closes the corresponding zone cold duct damper opens.

Low velocity ductwork connections are made up to appropriate groups of dampers to suit particular zones to be served; the hot and cold air streams are mixed within each duct in the correct proportions to satisfy the load conditions as dictated by a room or zone thermostat.

5.12 Diffusers, Registers, Grilles and Jet Nozzles

5.12.1 General

Diffusers, registers, grilles and jet nozzles shall be designed, selected and positioned to provide even, draught free air distribution and movement within air conditioned or ventilated rooms or areas of buildings and enclosures.

The units shall be suitable for ceiling, side wall or floor mounting as specified; manufactured from formed sheet steel or extruded aluminium section with particular attention being paid to squareness, uniformity and standard of finish.

All units should be complete with all necessary fasteners, fixings, sealing gaskets and rings, and plenum boxes as required for ease and simplicity of installation. Where possible, fixings shall be of a concealed type.

Air velocities through the units should be such that noise generation is below the specified limit and due allowance shall be made for partially closed volume control dampers.

All diffusers, registers and grilles shall be provided with an appropriately designed volume control damper mounted upstream, key adjusted through the face of the units.

Vanes or blades may be specified to run in the short or long dimension of the unit, be of adjustable or fixed form, single or double row.

Where possible, supply and extract registers and grilles shall be matched in appearance. Transfer grilles shall be of the non-vision type.

5.12.2 Diffusers

Diffusers should be selected for supply air application; however, matching types shall be used for extract air in the same room or location; they may be of circular, square or rectangular pattern with fixed or adjustable blades or continuous slot linear type.

Square and rectangular diffusers may be arranged for 1, 2, 3 or 4 way air diffusion. Adjustable blades shall provide horizontal or vertical discharge.

Linear diffusers may be single or multiple slot and shall be adjustable for horizontal, vertical or intermediate direction of air flows.

Where high air volumes are required, perforated face diffusers, complete with spigot and acoustic box should be considered.

Circular diffusers offer good air entrainment and provide efficient diffusion of large quantities of air.

5.12.3 Registers & Grilles

Registers and grilles may be selected for supply, extract or transfer air applications. They may be square or rectangular shape with removeable centre cores of either fixed or adjustable blades.

5.12.4 Jet Nozzles

Jet nozzles shall be for supply air function only. They shall be of either fixed or adjustable drum type or swivelling ball type designed for long throw or diffused air pattern for personnel/spot cooling.

Multiple fixed drum arrangements may be used to achieve high induction air movement.

5.13 Fire Dampers

Fire dampers shall be provided in ducted air distribution systems as required by local authorities and by fire regulations. In general fire dampers will be required where air ducts pass through fire compartment walls or fire rated shafts and floors.

Fire dampers shall be manufactured from steel at least 1.6 mm thick and shall be held open by a fusible link or frangible bulb set to fail at 70°C. The assembly should have at least the same fire resistance as the structure through which the duct passes.

Replacement of the fusible link or frangible bulb shall be possible without dismantling other components of the fire damper.

Fire damper blades should be of aerofoil profile for minimum resistance to air flow when fully open. The blades and linkages shall be capable of

operation under the maximum system operating conditions. Multiblade dampers should have opposed blade operation.

Fire dampers for use on high velocity distribution systems should be the interlocking curtain type with the blades located outside of the air stream to avoid excessive friction losses and noise generation.

Where fire dampers are required to interface with Fire and Gas or safety shut-down systems they shall be complete with solenoid operated electro or pneumatic actuators of the spring return fail safe type designed to close on failure. Limit switches for remote indication and position indicator shall also be provided.

Automatic or manually controlled fire dampers shall have a closure time not exceeding 3 seconds.

All fire damper controls, actuators, solenoid valves, limit switches, etc., should be arranged in a control housing or enclosure mounted external to the damper casing. The enclosure should be complete with removable access cover for maintenance purposes.

The facility to by-pass the frangible bulb operation shall be provided to all dampers, either pneumatic or electrically operated. This facility shall only be operated under controlled conditions.

5.14 Pressure Control Dampers

Pressure control dampers shall be provided in ductwork distribution systems where it is necessary to maintain accurate design air pressure differentials within the buildings or enclosure.

The dampers should be designed to modulate air flow rate in response to change in a control variable.

Positive air pressures shall be maintained by modulating extract flow rates, while modulating supply air flow rates shall control negative pressures.

Automatic pressure control damper construction shall include multiple aerofoil blades arranged in opposed blade action. Blade shafts shall be supported in sealed ball bearings which are easily replaceable from outside the damper casing. The dampers shall be complete with actuator/positioner controller and position indicator all contained within an enclosure mounted external to the casing.



Simple mechanical pressure relief dampers shall comprise multi-blade configuration arranged for parallel operation contained in a flanged steel casing.

The blades shall be interlinked externally and incorporate an adjustable tension spring or weight which shall keep the damper closed under back draught or non-operating condition and which will allow the damper to open as the upstream pressure increases.

5.15 Volume Control Dampers

Volume control dampers shall be designed to control the flow of air in the ductwork system by varying the resistance to flow. They may be hand operated balancing dampers when their normal use is to achieve initial regulation of air flows, or automatically operated control dampers to provide air mixing, bypass or throttling control.

Single bladed dampers shall be restricted to small duct sizes where accurate control is not essential.

Iris dampers employed in circular ducts shall consist of moving leaves that form a variable orifice.

Multi-leaf, multiblade dampers shall comprise two or more blades linked together to operate in parallel or opposed action, i.e. all blades rotate in the same direction, or opposite direction.

Hand operated dampers should be provided with a lockable operating quadrant/position indicator.

Mixing dampers may comprise two or more dampers, mechanically interlinked such that as one opens the other closes, and interlocked through the control system to operate in unison.

Selection of automatic dampers shall take into account the required flow characteristic, pressure drop and mechanical suitability for the application. The damper actuator and pilot positioner should have the required timing, stroke and torque rating.

5.16 Shut-Off Dampers

Shut-off dampers shall be employed in ductwork systems to automatically isolate equipment or sections of ductwork in the event of air flow failure or an incident. They will be particularly employed on fan discharges to prevent air recirculation during change over of

running and stand-by fan sets and to allow large fan sets to run up to speed against closed damper to avoid fan motor overload.

The dampers shall operate on a two position basis (open or closed) to give minimum restriction to airflow when open and tight shut-off when closed. Suitable gaskets or seals shall be provided on the blades to ensure tight shut-off. The closure time of these dampers shall not exceed 3 seconds.

Damper construction shall be similar to pressure control dampers (see 5.14), excluding the pilot positioner. The dampers should be complete with solenoid controlled spring return fail safe actuator, position indicator and limit switches for remote indication, all contained in an enclosure mounted external to the casing.

5.17 Non-Return Dampers

Non-return dampers shall be located in ductwork systems to prevent reverse flow of air in the system.

The dampers shall comprise multiblade or butterfly arrangements designed to open in the direction of the air flow only under the influence of the air stream pressure and to close during system shut-down or during back draft conditions.

The blades on non-return dampers shall be interlinked to ensure they all operate in unison.

Dampers bearings shall be of self lubricating type.

5.18 Blast Dampers

Blast dampers shall be incorporated within structural openings of fresh air intake and exhaust air discharge points in blast-proof control buildings.

The blast dampers shall comprise a steel framework for bolting into the structure together with bolted steel backing plates and banks of spring steel damper blades bolted to the backing plates to form the composite blast damper arrangements.

The spring damper blades shall allow free passage of air flow during normal operation, but shall react to fully close in milliseconds due to the pressure wave and suction phase of explosive incidents and shall return to the normal position when the pressure is abated.



Refer to [BP Group RP 4-6](#) for blast load conditions.

5.19 Acoustic Attenuators

Attenuators shall be factory made units designed for mounting in ductwork systems to reduce the transfer of mechanical and air-generated noise within the ductwork. The attenuators shall provide a high, broad band insertion loss per unit length.

Units shall be normally constructed with outer metal casing of rectangular or circular cross-section fitted with internal lining and splitters of sound absorbing material within air passage ways. The facing of splitters or lining should be of dense absorbing material or perforated or expanded metal. The whole arrangement shall be aerodynamically and acoustically designed to provide maximum acoustic performance with minimum resistance to air flow.

Splitters shall be mounted in the vertical plane to prevent sagging.

Specific attention shall be given to avoid turbulent air flow at entry and exits of attenuators, to ensure optimum performance and to prevent noise regeneration taking place.



5.20 Air Terminal Units

5.20.1 General

Air terminal units are normally associated with high velocity high pressure air systems to provide a means of converting the high velocity, high pressure primary air to low velocity, low pressure secondary air suitable for discharge into the rooms or enclosures.

The units shall comprise an acoustically lined box incorporating a static pressure regulator and sound baffles together with high velocity inlet and low velocity outlet air flow connections.

The units may be single duct type with one primary air connection or dual duct mixing type for use with hot and cold dual duct primary air systems. Dual duct mixing boxes shall be provided with an additional motorised inlet mixing damper, which under the dictates of room or space thermostats shall control the mixture of hot and cold air streams to maintain design temperature conditions.

The units may be supplied in different arrangements to suit specific applications as follows:-

5.20.2 Constant Volume

These units shall be provided with factory set constant volume regulators to maintain a constant supply air flow at low velocity to the rooms or spaces against variations in pressure in the primary air duct pressure. The units shall have the capability of manual site adjustment and should be available for both single duct and dual duct applications.

5.20.3 Variable Air Volume

These units shall incorporate a flow throttling damper arrangement in addition to the static pressure regulator. The units should supply air at constant temperature, the flow rate being decreased as the cooling load reduces to maintain design conditions. With dual duct variable air volume units, the cold duct mixing damper should be fully open for maximum cooling with the hot duct damper fully closed until the cold duct reaches its minimum setting in response to a decrease in cooling load. Any further decreases in cooling load should result in the opening of the hot duct damper.

5.20.4 Reheat

For multi-room or multi-zone buildings supplied with centrally treated and distributed air at a common temperature, controlled to satisfy the greatest cooling load in any room or zone, the internal design conditions in other rooms and zones may be maintained by electric or hot water re-heat coils provided integrally with the terminal units.

Constant volume and variable air volume units may be provided with terminal re-heat coils.

5.21 Fan Coil Units

Fan coil units shall be package assemblies comprising water heating and cooling coils, condensate drain trays, circulating fans and filter unit all contained within a single casing having bottom air inlet and top air discharge facilities.

Alternatively, the units may be mounted in the horizontal plane. This requirement shall be confirmed to the supplier.

The units shall be suitable for applications with intermittent loads and are best located at room or zone external perimeters. The units may incorporate a fresh air facility.

Heating or cooling output control shall be achieved by modulating valves in the water distribution systems in response to local sensors.

5.22 Induction Units

Induction units shall comprise arrangements of hot and chilled water coils contained within a sheet metal casing complete with primary airway and nozzles; air-way for induced room air to pass over the coils to discharge through grilles into the room or space.

Coils may be combined dual function (hot and cold) for all pipe arrangements, or separate heating and cooling for three or four pipe arrangements.

The units shall normally be arranged with vertical air discharge for siting at windows on perimeter walls. A simple lint screen is usually provided as a means of filtering the induced room air; filtering and conditioning of the primary air is achieved at the central plant.

5.23 Refrigeration Plant

5.23.1 General

Refrigeration plant for air conditioning in buildings and enclosures should be supplied in the form of packaged units for mounting directly on solid foundations or on resilient mountings where it is necessary to minimize transmission of noise and vibration.

The package units shall comprise arrangements of compressors and drives, evaporators, condensers, control panels, together with all necessary controls and interconnecting piping and cabling.

Compressors should be the vapour compression type; evaporators may be flooded shell and tube type producing chilled water, or dry direct expansion type where the refrigerant is used directly as a cooling medium; condensers may be air cooled type or shell and tube water cooled type.

In multi-compressor installations, isolating valves shall be installed to facilitate a compressor in-situ repair or removal, but still permitting the remaining compressors and cooling circuits to operate. Compressor protective devices and instrument gauges shall be arranged to meet this requirement.

Only non-CFC refrigerants shall be used.

In accordance with the Montreal Protocol and subsequent Directives, the production and use of CFCs' is being phased out.

Absorption type water chillers using lithium bromide as an absorbant shall only be considered for very large installations where a constant supply of hot water or low pressure steam is readily available or where electrical supply is limited.

Heat rejection from absorption type water chillers is generally double that of vapour compression machines, hence very large cooling towers will be required for satisfactory operation. Although noise and vibration are very low and up to 10% turndown on capacity is attainable, the units must be maintained at a high vacuum for correct functioning; any leakage may cause internal corrosion or crystallization of the lithium bromide.

Vapour compression systems may be classified by the type of compressor utilised, as follows:-

5.23.2 Reciprocating Compressors

Capacity control shall be by means of cylinder unloading in equal steps which shall determine the design and operating temperatures of chilled water systems.

Reciprocating compressors shall have either hermetic, semi-hermetic or open drive motor configurations.

Available in a wide range of sizes and designs, they are generally used in packages of up to 300kW of cooling capacity although ratings in excess of 1000kW are available.

Fully hermetic machines with the compressor and motor enclosed in a pressure vessel are not serviceable and shall be normally confined to low output units up to 15kW of cooling capacity.

Semi-hermetic machines are most frequently used; they are more compact, quieter and reliable than open type machines. They may be serviceable, although to avoid introduction of moisture into the system, which can damage the motor, servicing should only be carried out by skilled and competent personnel.

Open drive compressors are easily serviceable but they require more floor space and their reliability depends on the effectiveness and performance of the drive shaft seal between compressor and motor. Their use should be considered where competent inhouse maintenance staff are available and where rapid remedial action is required.

5.23.3 Centrifugal Compressors

They shall generally incorporate two stages of compression with an interstage economiser to improve efficiency. Modulated control approaching 10% of full rated capacity shall be attainable, in conjunction with condensing pressure control.

Centrifugal compressors may be direct driven or driven via a speed increasing gear train and may be semi-hermetic (thereby eliminating the need for drive shaft seal) or open drive.

Centrifugal compressors are best suited for large capacity installations; they are generally available in factory assembled units of 750KW cooling capacity and upwards.

Centrifugal machines shall have minimum moving parts which leads to reliable operation and infrequent need for maintenance overhaul.

Care must be exercised to prevent fouling of the condenser, partial failure of condenser coolant flow and accumulation of air in the compressor as any of these can lead to 'surging' caused by unstable refrigerant flow through the compressor.

Surging, characterised by a significant rise in noise level, may cause damage to the compressor and drive motor.

Low output units, operating with low pressure refrigerants with evaporators operating below atmospheric pressure may be particularly at risk from leaks that can draw air and moisture into the system.

5.23.4 Screw Compressors

Capacity control, down to 10% output, shall be achieved by varying the compressor displacement by means of a slide valve to retard the point at which compression commences.

Units incorporating a flooded evaporator require an oil recovery system to remove the small quantity of lubricating and seal oil injected into the compressor, which will collect in the evaporator.

Oil coolers shall be provided on units which utilise the oil to remove some of the heat of compression.

Drives may be semi-hermetic or open as described in 5.23.3. The machines shall be suitable for use with both shell and tube water cooled and air cooled condensers.

Screw compressors generally follow the same application consideration as centrifugal machines.

Two types are available, high speed single or high speed twin screw, both are positive displacement machines which avoid the risk of surging and reduction of capacity due to high condenser pressures.

5.23.5 Evaporators

5.23.5.1 General

Refrigeration plant evaporators shall be refrigerant direct expansion cooling coils or shell and tube cold water generator type forming an integral part of the refrigeration plant package to generate cold water for use with chilled water cooling coils.

5.23.5.2 Refrigerant Direct Expansion Type

Refrigerant direct expansion cooling coils shall be generally as described in 5.9.

They may be arranged for mounting in ductwork or within air handling units as part of 'Split System' refrigerant plant.

5.23.5.3 Shell and Tube Type

Shell and tube evaporators may be either the flooded type or dry evaporative type, depending upon application.

Flooded type shall be arranged for water flow through the tubes with refrigerant in the shell giving flooded operation and high rate of heat transfer. These units shall be suitable for all duties, they may accommodate large fluctuations in load, require a large refrigerant charge and shall be suitable for generating chilled water down to 4°C. Capacity control shall be generally achieved by a refrigerant expansion device sensitive to refrigerant liquid level in the shell.

Dry evaporative type shall be arranged for water flow through the shell with refrigerant through the tubes. The units require a smaller refrigerant charge than the flooded type of evaporator, and are suitable for water temperatures down to 4°C and duties up to 750kW. Capacity control shall be achieved via thermostatic expansion valves which limits flexibility.

Shell and tube evaporators comprise a welded pressure vessel containing a heat exchange surface in the form of finned tubes located between tube end plates and having removable end covers to provide access to the tubes.

5.23.6 Condensers

Condensers may be either the water-cooled shell and tube or air-cooled type, depending upon application.

The heat of compression absorbed by the refrigerant as part of the refrigeration plant cycle is rejected at the condenser to return the refrigerant to its liquid state before entering the expansion valve.

5.23.6.1 Water-Cooled Shell and Tube

Condenser pressure control shall be maintained by controlling cooling water temperature. This shall be achieved by by-passing the cooling tower to give constant flow through the condenser at varying temperature; this prevents low water velocities through the tubes which could lead to increased fouling. Throttling water flow through the condenser is not acceptable as this causes surging in the compressor.

Double bundle condenser arrangements shall be available for heat reclaim, where the heat is rejected by two systems. One to the cooling tower and one to the air conditioning system.

Water-cooled shell and tube condensers are suitable for a wide range of duties. Normally associated with large packaged units, they comprise a welded pressure vessel (or shell) containing condensing surfaces in the form of copper finned tubes held between tube end plates and having removeable end covers to provide cleaning access to the tubes. The refrigerant circulates in the shell while the cooling water circulates through the tubes. The arrangements generally operate in association with cooling towers to recool the water.

5.23.6.2 Air-Cooled Condensers

The coils shall be of copper with aluminium fins; copper fins may be required in severe or saline locations, and shall be tinned after manufacture.

The larger sized units shall generally be arranged with the coils in a flat horizontal configuration with vertical air flow to present the lowest profile least affected by wind conditions.

Air-cooled condensers should be located away from down draughts caused by wind flow over and around adjacent buildings.

In large units, condenser pressure control shall be achieved by varying the air flow over the tubes, i.e. by fan speed control. In smaller units it shall be achieved by causing liquid refrigerant to partially fill the tubes and thereby reduce the effective cooling surface. This method calls for a receiver to store the additional refrigerant.

Generally for use with smaller systems, these units require very large volumes of air to function properly. They are of relatively large physical size and require more fan power than cooling towers or evaporative condensers.

The units comprise banks of finned coils through which hot refrigerant gas is circulated and over which atmospheric air is drawn or blown by fans to absorb the heat.

5.23.6.3 Evaporative Condensers

Evaporative condensers are not frequently used in air conditioning systems. They comprise a refrigerant tube bundle enclosed in a sheet metal casing through which air is blown and over which water is sprayed to provide cooling as it evaporates into the air stream.

Condenser pressure control is similar to that employed for air cooled condensers.

Evaporative condensers will be less efficient and more costly than other types.

5.24 Unitary Equipment

5.24.1 Room Air Conditioners

Room air conditioners also known as window or through-the-wall units shall be self contained packaged units incorporating a room side evaporator (direct expansion cooling coil), an external air cooled condenser, compressor, integral controls and an electric heating coil.

These units offer a very basic form of air conditioning. Control is by compressor cycling with consequent swings in room temperature and humidity. Room noise levels are increased when the unit is in operation. The units generally only require an outside wall for mounting, a suitable electric power supply and condensate drain.

5.24.2 Unit Air Conditioners

These units shall be small or medium capacity units comprising air handling equipment and refrigeration plant within a self contained skid mounted packaged enclosure. The units shall be suitable for external (roof) mounting or suitable for internal location as free standing units. The condenser may be water cooled or a remote or combined air cooled unit.

5.25 Split System Air Conditioning Units

Split system air conditioning units shall comprise a local air handling unit containing a refrigerant evaporator (direct expansion cooling coil) interconnected via refrigerant piping to a remote skid mounted condenser set comprising compressor, condenser, fans, motors and controls.

5.26 Cooling Towers

5.26.1 General

Mechanical draught type cooling towers shall be used in HVAC applications for the cooling of refrigeration plant condenser water.

Grilles and filters should be provided to limit entry and build up of dirt and other debris carried by the air stream.

Cooling towers generally comprise a metal or wood superstructure containing packing of treated wood or plastic material over and through which the condenser water is sprayed via an array of pipes and spray nozzles. Air is induced or forced through the towers by fans to be discharged at high level.

The cooled condenser water is collected in trays or basins in the bottom of the tower for conveying back to the refrigeration plant condenser.

5.26.2 Selection

Factors to be considered when selecting cooling towers are as follows:-

- condenser water flow rate and temperature range through which it is to be cooled
- design ambient wet bulb temperature
- any limitations on height, plan area requirements, operating weight, noise and vibration or aesthetic requirements siting with regard to adjacent walls, windows and buildings and effects of any water carried over by the air stream.
- siting with regarding to exhaust heat or contaminated air from other process plant materials of construction for tower and fill effect of high ambient or solar radiation temperatures when the tower is not in use
- fire risk
- wind effects
- maintenance access

5.26.3 Induced Draught Towers

Induced draught towers may be either the counter flow or cross draught type, depending upon application.

Slow speed, low noise fans shall be used and discharge vertically at high velocity to minimise the chances of air recirculation.

Mechanical moving parts will be more readily accessible, but the risk of recirculating saturated air is higher if the units are located in a confined space.

Induced draught towers have fans positioned at the air outlet from the tower, normally on the top but sometimes in the side or in ducting.

The mechanical moving parts however, will be positioned in a hot humid air stream and are not so readily accessible for maintenance. Also with fans located at the top of the tower superstructure, vibration must be given special attention.

There are two versions of induced draught towers:-

- (a) Counter Flow: the fans induce a vertical flow of air up through the tower packing over which the condenser water flows in the opposite direction for maximum performance i.e. coldest water in contact with driest air.*
- (b) Cross Draught: the fans induce a horizontal airflow through the vertical water fall. These units require more floor space but have much lower silhouette, blending well with architectural requirements.*

5.26.4 Forced Draught Towers

Forced draught towers utilise fans located at the air intake to blow ambient air into the tower, up and across the packing in counter flow direction to the water flow. The air is discharged at the top of the tower.

Air discharge should be maintained at high velocity to avoid risk of recirculation of saturated air stream.

The mechanical equipment at the base of the tower is readily available for maintenance access. Fan sizes are limited however and a larger number of smaller, high speed (hence noisier) fans will be required compared to induced draught towers.

The power requirement for this type of tower is usually greater than for the induced draught type.

5.26.5 Closed Circuit Towers

For certain applications, fouling or corrosion in the cooling water system may be unacceptable. In these cases closed circuit cooling towers shall be used in which the condenser water is circulated through cooling coils within the tower while a completely separate water supply is recirculated through the tower and over the coils to achieve condenser water cooling.

Fouling and corrosion is restricted to the external surface of the cooling coils, the condenser water within the coils remaining clean.

Condensing efficiency will be less than for open towers due to the extra stage of heat exchange involved.

5.26.6 Water Treatment

Water treatment shall be provided to maintain the circulating tower water at appropriate conditions. pH should be controlled between 8.5 and 9.0 and biocides employed to prevent algae, bacteria or slime



developing in the tower. In addition an automatic blowdown shall be provided to limit the concentration of dissolved solids.

Treatment to eliminate the growth of *Legionella pneumophila* shall be provided.

Regular analysis of the cooling tower water shall be carried out to verify that bacterial contamination is not present or is being effectively controlled.

Cooling tower return water basins or sumps are generally fairly shallow: with high circulating rates at peak operating conditions water change rates in the order of 1.5 to 3 per hour will be common resulting in a concentration of solids amounting to several kilograms daily if the water is hard. If the water is soft, acidic conditions may develop particularly if the tower washes out airborne contaminants in the form of sulphur dioxide from the atmosphere.

5.27

Pumps

'Heating' and 'cooling' water services pumps for HVAC applications should generally be single stage centrifugal type.

Pumps shall be provided with mechanical seals and heavy duty ball bearings in combination with sleeve bearings as applicable. All pump materials in contact with water shall be selected to avoid corrosive or electrolytic attack.

Pumps, motors and drives shall be readily accessible for operation, maintenance and repairs. Close attention should be paid to the pump inlet and outlet configurations and position of isolation valves, non-return valves and strainers to avoid excessive pressure drop.

Pumps shall be located such that a net positive suction head is maintained with the pumps remaining fully primed during starting and running conditions.

Pump connections shall be flexible, or pipework adjacent to the pumps shall be supported by flexible hangers to avoid unacceptable loads and transmission of noise and vibration into the piping system or building. Electrical power connections to the motors shall also provide flexibility.

Full consideration shall be given to the consequences of a leak caused by failure of pump flexible connections in high head installations. Where the risk and consequences are deemed to be severe, the pipework and hangers shall be specially designed to attenuate vibration in lieu of flexible pump connections.



Pump motors and drives are available in the following configurations depending on size, duty and application.

- (a) *Direct Coupled:* with the pump and motor mounted on the same baseplate, the motor drives the pump through a flexible coupling. The pump has its own bearing, duty is adjusted by varying the impeller diameter.
- (b) *Belt Drive:* where the pump has its own bearing and baseplate and is driven by the motor mounted on slide rails either at the side or on the top of the pump. Duties may be varied by selecting pulleys to run at the appropriate speed.
- (c) *Close Coupled:* where the impeller is fitted to an extended motor shaft which enters the casing. The motor bearing shall withstand all the thrust developed by the pump. This arrangement is suitable only for the lower range of duties.
- (d) *Inline:* with the pump casing arranged to provide inlet and outlet connections on the same centre line for ease of installation.
(floor mounted)
- (e) *Inline:* similar to floor mounted inline but of light enough construction to be fitted safely into the pipework system. Generally limited to lower range of duties.
(pipeline mounted)

5.28

Heat Exchangers

Heat exchangers for use with HVAC systems may be non-storage shell and tube type, or high efficiency plate type, depending on the primary medium, i.e. steam, hot or cold water.

The end plates shall be removeable to provide access for cleaning the tubes, local primary heating or cooling pipework shall incorporate short removeable final connections, provided with suitable couplings for this purpose.

Exchanger plate material shall be stainless steel type 316 for normal applications. Titanium plates shall be provided for heavily chlorinated or sea water.

The exchangers may be arranged for vertical or horizontal mounting on feet or cradles and should be complete with flanged or screwed primary and secondary flow and return connections together with all necessary branches for safety valves, pressure and temperature gauges, drain cocks and vent lines.

Shell and tube heat exchangers generally comprise a welded mild steel shell, cast iron or steel steam/water chest end plates with extended surface copper tubes

expanded on to steel or non-ferrous tube plates arranged for single or multi-pass as required.

Plate heat exchangers generally comprise a series of specially formed corrugated herring bone pattern plates arranged to achieve maximum turbulence with true primary and secondary fluid counterflow to provide a high heat transfer efficiency.

The plates will be mounted on a frame between fixed and moveable end plates drawn together via extended tie bolts. The plates will incorporate double-jointed butyl rubber gaskets to prevent cross-flow contamination of the primary and secondary fluids.

5.29 Heat Recovery Systems (Air)

5.29.1 General

Equipment for this purpose necessitates the exhaust discharge and fresh air intake streams to be in relatively close proximity.

The increasing need for energy conservation has led to the development of various types of heat recovery/reclaim devices. Adoption of a particular system must be economically justified, a two/three year return on capital investment would be typically considered viable.

5.29.2 Run-Round Coils

This system comprises individual heat exchange coils located in the supply and extract air streams of large systems and interconnected by a pumped water piping system. The system shall be thermostatically controlled such that the pump operates only when the external air temperature is below the design exhaust temperature or, alternatively, the pump only operates when the exhaust air temperature is higher than the supply air temperature.

5.29.3 Air-to-Air Heat Exchangers (Crossflow-Stationary Recuperators)

These units consist of factory packaged items comprising an enclosure containing an arrangement of parallel air paths separated by metal or glass vanes. Heat is transferred from the warm exhaust air stream to the cooler fresh air stream across the walls of the unit in a counter flow effect for maximum efficiency.

The units offer reasonable transfer efficiencies and are practically maintenance free. Relatively large and complex ductwork arrangements will be required to convey the intake and exhaust air streams through the units, which may be considered a disadvantage of the system.

5.29.4 Thermal Wheels

Thermal wheels comprise a heat retaining material rotating in a casing driven by an electric motor. The casing is divided such that the exhaust air passes through one segment of the wheel in one direction and the supply air passes through a

different segment in the opposite direction. As the wheel turns heat taken up in warm exhaust stream is transferred to the cooler outside air stream.

The units shall incorporate a purging section to prevent any transfer of contaminants from the exhaust.

5.30 Automatic Controls

5.30.1 General

Automatic control systems shall be designed to control temperatures, humidity and pressures within the occupied space to maintain the following:-

- (a) a safe and comfortable environment for personnel, suitable conditions for process equipment operation and protection, and for the shelf life and quality of stored products.
- (b) prevention of over-heating or cooling; efficient economic operation to reduce energy consumption
- (c) permit conditions to be controlled and adjusted within pre-set limits.

5.30.2 Functions

The controls system shall include the following functions.

- (a) Control - To maintain temperature, humidity and pressure at desired levels within predetermined limits.

To meet these requirements, control devices will incorporate the following control actions as appropriate to the application:-

- (i) *two position control*
 - (ii) *proportional control*
 - (iii) *proportional plus integral action*
 - (iv) *proportional plus integral plus derivative action*
- (b) Safety - To prevent temperatures, humidities or pressures exceeding safe limits and prevent equipment operating beyond them.

- To provide means of interfacing with fire and gas detection and smoke control systems.
- (c) Operation - To provide means to stop and start the HVAC systems in a predetermined sequence; to provide economical operating cycles to match HVAC system output to load conditions.

5.30.3 Performance

Design of HVAC systems and associated controls system shall be considered together to achieve optimum performance and economic operation.

Heating and cooling equipment and components, control valves and dampers shall be sized so that controls components can be properly matched.

System load changes and variations shall be analysed together with time lag effects.

Correctly selected control devices will therefore take into account the following:-

- (a) Construction and thermal capacity of the building.
- (b) Types and thermal response of the HVAC system.
- (c) Use of building and hours of occupation.

All HVAC control equipment and components shall be capable of adjustment to deal with maximum and minimum conditions plus intermediate load conditions.

Controllers and sensing elements for all applications shall be located where they measure a truly representative condition not influenced by solar effects, draughts, vibration, lighting, abnormal heat conduction or fluid stratification or stagnation.

Control valves and dampers shall be sized and selected with sufficient pressure drop compared to the system head, to provide correct control authority.

Incorrectly matched HVAC components and automatic controls will lead to poor and in some circumstances, uncontrollable conditions.

Quality and accuracy of control equipment should be consistent with accuracy of control required. Control equipment, capable of providing more precise control than the application requires will be under utilised and therefore uneconomic.

5.31 Insulation

5.31.1 General

Insulation, whether thermal or acoustic shall comply with the requirements of [BS 476](#), the appropriate sections of [BP Group RP 52-1](#) and in particular to the requirements for control of flamespread and toxicity.

In the absence of a BP supplementary specification for insulation, the following text should be used as broad outline guide only.

HVAC equipment, piping and ductwork shall be provided with thermal, acoustic and fire protection insulation as required to:-

- Satisfy Local Regulations and Bylaws
- Conserve energy, i.e. prevent undue heat gains or losses or formation of condensation
- Provide protection for personnel
- Reduce plant generated and air borne noise
- Provide protection in the event of fire.

Insulation materials shall be proof against rotting, mould and fungal growth and attack by vermin; be non-hygroscopic and odour free at the design temperatures ranges.

The materials shall not contribute to the spread of fire or smoke; if combusted they shall not produce dense smoke or toxic fumes.

Adhesives shall be non-combustible and shall be compatible with the insulation. Additional fixings in the form of spire pins and clips may be required.

Insulation shall not be applied until pressure/leak tests are complete for the pipework or ductwork.

[BS 476](#) Parts 7 and 8 refer.

5.31.2 Thermal Insulation

Thermal insulation shall be applied to hot or cold surfaces in large slabs, continuous rolls or rigid sections as per specification to maintain maximum continuity of insulation.

Insulation on bends and fittings should be formed from mitred and trimmed sections cut to ensure a good contact with the surface to be

insulated. Continuity should be maintained by firm butting together with adjacent slabs sealed with self adhesive vapour barrier type tape, or hand applied sealer.

All rigid sections should be accurately matched in thickness with no steps or undulations apparent on the surface.

Insulation on cold surfaces shall be provided with an external vapour barrier to prevent the formation of condensation on or within the insulation.

The vapour barrier shall not be pierced by supports, and load distribution sleeves should be provided where necessary. At points of discontinuity the vapour barrier should be returned and sealed to prevent entry of moisture.

In general only materials with low thermal conductivity throughout their entire working temperature range should be considered.

Thermal insulation exposed to the weather shall be rendered completely waterproof by an external cover or cladding which shall be proof against deterioration with age or the effects of solar radiation.

Thermal insulation exposed within plant rooms shall be clad to a height not less than 2.0 m from floor level with appropriate metal or plastic materials.

5.31.3 Acoustic Insulation

Acoustic insulation to ductwork shall take the form of heavy density glass fibre or mineral wool slab liner. The liner surface shall be faced with neoprene or similar reinforced membrane to provide a non-taut, porous, sound absorbing surface free from 'fibre fly' or erosion fragmentation.

Acoustic insulation shall be applied internally to ductwork and equipment casings to limit transfer of noise into the space, and applied externally to avoid noise 'break-in' where the ductwork systems pass through noisy plant areas.

Where acoustic lining is applied within high velocity ductwork, light gauge galvanised perforated plate shall be utilised and fixed to the ductwork to retain the material.

It should be noted that acoustically lined ductwork bends offer more effective noise attenuation than lined straight sections.



Acoustic treatment to the outside of equipment or ductwork in exposed locations or plantrooms, shall be clad with galvanised or stainless steel sheet suitably fixed and sealed.

5.31.4 Fire Protection Insulation

Fire protection insulation to ductwork and equipment shall generally be provided as required to maintain the fire rating integrity of enclosures through which they pass.

Fire protection insulation shall be achieved by external application of rigid mineral wool slabs of suitable thicknesses and density to provide one or two hour non-hydrocarbon fire rating as required by the local regulations (Building Regulations in the U.K.).

For hydrocarbon applications, e.g. refineries, fire protection insulation shall be achieved by the external application of 75 mm thick rigid mineral wool slabs having a density of 110kg/m². This shall be applied in two layers, i.e. 50 mm + 25 mm having staggered joints.

The material shall be adequately secured by metal spine clip fasteners and wire mesh to prevent the material sagging under its own weight. The assembly shall be protected by stainless steel cladding where it is susceptible to damage, i.e. in plantrooms.

External fire rating cladding shall include a pre-bonded moisture barrier, the total arrangement shall be weatherproofed and all joints sealed.

6. COMMISSIONING AND TESTING

6.1 General

Commissioning and testing shall be carried out to ensure that the installations are acceptable before hand over to the Client. Sufficient time for these activities shall be allowed in the construction programme. All results shall be properly documented, and dated, and included in the hand over documents.

6.2 Works Testing

Works testing of equipment and components shall be carried out at all stages of manufacture as required by the Client. Fully fabricated equipment and components shall be functionally performance tested prior to delivery/shipment.

6.3 Pre-Commissioning

Mechanical completion sheets (for example list see Appendix E) shall be completed and signed. No mechanical equipment item shall be made live until these forms are completed.

Pre-commissioning checks shall be carried out on completed installations to ensure their readiness for start-up prior to full commissioning.

Pre-commissioning checks will include:-

- (a) equipment and plant installed in accordance with manufacturer's instructions.*
- (b) hook-up to utilities is complete (power, water, instrument air, steam) including temporary service if required.*
- (c) ducting system pressure/leak tested and thoroughly cleaned.*
- (d) piping systems flushed through, hydraulically tested, and refilled including the addition of the correct type and quantity of corrosion inhibitor and biocides.*
- (e) domestic water supply systems thoroughly cleansed/sterilized in accordance with recommended practice.*
- (f) control components completely installed and calibrated in accordance with manufacturers instructions.*
- (g) instruments loop checks complete.*



- (h) *all safety devices, interlocks and cut-outs in position and functioning correctly.*
- (i) *refrigeration systems dehydrated, pressure tested and fully charged, control circuiting sequence tested offload.*

6.4 System Commissioning

Commissioning HVAC installations and systems shall be carried out in accordance with the procedures described in the following CIBSE Commissioning Codes:-

Code	A	Air Distribution
	B	Boiler Plant
	C	Automatic Control
	R	Refrigeration
	W	Water Distribution

Commissioning shall be performed by specialist companies who employ experienced and competent personnel and who provide all necessary commissioning instruments and equipment.

6.5 Site Testing

Testing to evaluate the performance of commissioned installations shall preferably be carried out under actual operating conditions usually after the buildings have settled down and are occupied.

This may involve a two stage testing period to cater for summer and winter seasons, therefore appropriate arrangements should be planned and programmed.

All equipment items and systems shall be tested to prove that operating capacities and performance are in accordance with specifications and that all control interfaces with other systems, such as Fire and Gas, operate as required. All safety facilities shall be proven.

The systems performance shall be demonstrated to Certifying Authorities and the Client as required.

7. DOCUMENTATION

* 7.1 Design Drawings

Detail design drawings of the HVAC system shall indicate the full scope of work including construction, installation and all necessary interfaces for proper co-ordination with other disciplines.

All drawings shall be produced to standard sizes and shall be suitable for micro filming or electronic storage.

Drawings which are necessary for Client approval shall be agreed with the Contractor.

The following are typical requirements:-

- (a) General arrangement drawings showing HVAC plant and equipment layouts, co-ordinated with other services within the building.*
- (b) Routing drawings for ductwork.*
- (c) Routing drawings for pipework and drainage.*
- (d) Routing drawings for HVAC power and control cabling.*
- (e) Routing drawings for instrument air piping.*
- (f) Engineering flow diagrams for air and water systems.*
- (g) Controls schematic diagrams (ladder format) and instrument schedules.*
- (h) Detailed ductwork drawings.*
- (i) Detailed pipework drawings.*
- (j) Builder's work drawings for services, including equipment foundations.*

General arrangement drawings shall show plant/equipment layouts, routing and supporting of piping and ductwork, electrical cabling and control panels, maintenance access requirements, utilities connections, plant and equipment foundation and fixing details.

Where the installation relates to chemical or refinery buildings or any works involving potentially hazardous processes, 'Cause and Effects Charts' shall be produced for the operation of the building services.

Material purchasing or fabrication shall not commence before relevant drawings are approved by the Client.



7.2 Design Specifications

Detailed specifications of all the equipment forming part of the HVAC system design shall be prepared, ensuring that all design requirements for safe operation of the equipment and whole plant are incorporated.

7.3 Data Sheets

As a supplement to the equipment type specifications, data sheets shall be produced by the supplier for each item of equipment forming part of the design, setting out the specific performance and operating characteristics. Construction and installation details shall also be supplied.

7.4 Operational Philosophy

An Operational/Controls Philosophy shall be prepared to reflect the basis of the HVAC design which should address the following:-

- (a) Description of systems.
- (b) Mode of operation of the systems.
- (c) Control functions.
- (d) Control set points and limits for:-
 - (i) Room temperature and humidity control set points and limits.
 - (ii) Area pressurisation and monitoring.
- (e) Gas/smoke detection and control.
- (f) Interface with other systems, e.g. Fire and Gas/ESD.
- (g) Panel alarms, indications and repeats.
- (h) Process interlocks.
- (i) Start-up, shutdown and change over procedures.
- (j) Standby arrangements.
- (k) Emergency operation.

7.5

Installation, Operating and Maintenance Manuals

Manuals shall be prepared, clearly defining procedures for the safe operation and maintenance of mechanical heating, ventilating and air conditioning systems including refrigeration plant, ancillary equipment, piping systems and electrical installations.

The manuals shall include the following essential data:-

- (a) Full descriptions of HVAC systems and equipment including schedules of equipment, manufacturer's serial/reference numbers, performance curves, tables and charts.
- (b) Installation and operating instructions including start-up, operation and shutdown procedures and loop checks, adjustments and regulation, fault finding, remedial measures and safety precautions.
- (c) Routine maintenance schedules, procedures and records parts lists with reference numbers, spare parts lists, manufacturer's names, addresses and telephone numbers, details of service contracts and spares ordering instructions.
- (d) Systems 'as built' general arrangement drawings, flow sheets and valve charts.
- (e) Test sheets giving design and 'As built' values for the system.

DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory volume.

Abbreviations

AFFF	Aqueous Film Forming Foam
ASHRAE	The American Society of Heating, Refrigerating and Air Conditioning Engineers
CIBSE	Chartered Institute of Building Services Engineers
CFC	Chlorinated Fluorocarbon
ESD	Emergency Shut Down
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilating and Air Conditioning
HVCA	Heating and Ventilating Contractors Association
ISO	International Organisation for Standardisation
LEL	Lower Explosive Limit
OEL	Occupational Exposure Limit
QA	Quality Assurance
RMS	Root Mean Square

LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

International

[ISO 1940-1](#) Mechanical Vibration - Balance Quality Requirement of Rigid Rotors - Part 1 Determination of Permissible Residual Unbalance.

British Standards

[BS 476](#) Fire Tests on Building Materials and Structures, Parts 3 to 8.

[BS 3928](#) Method for Sodium Flame Test for Air Filters (other than for air supply to I.C. engines or compressors).

[BS 5141](#) Air Heating and Cooling Coils
Part 1: Method of Testing for Rating of Cooling Coils
Part 2: Method of Testing for Rating of Heating Coils

[BS 5720: 1979](#) *Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings.*

[BS EN 779: 1993](#) Particulate Air Filters for General Ventilation - Requirements, Testing, Marking (amended Nov '94).
(EUROVENT 4/5)

BP Documents

[BP Group RP 4-4](#) Buildings.

[BP Group RP 4-6](#) Procedure for the Design of Buildings Subject to Blast Loading

[BP Group RP 12-2](#) Electrical Systems and Installations - Electrical Equipment in Flammable Atmospheres & Combustible Ducts

[BP Group RP 24-1](#) Fire Protection- Onshore

[BP Group RP 52-1](#) Thermal Insulation

[BP Group GS 142-6](#) Piping Specifications



BP Standard Drawing

S-1240 Steam Trapping Arrangements (7 sheets)

Other Documents

CIBSE Guide to HVAC Design Commissioning Code.

CIBSE Building Energy Code

CIBSE documents are available from:-

Chartered Institute of Building Services Engineers, Delta House, 222 Balham High Road, LONDON SW12 9BS

EUROVENT 2/2 Air Leakage Rate in Sheet Metal Air Distribution Systems

Health and Safety Executive Guidance Note EH40 - Occupational Exposure Limits.

EUROVENT 4/5 Method of Testing Air Filters Used in General Ventilation

EEMUA 130 Design and Installation of On-Line Analyser Systems.

HVCA Spec DW 142 Specification for Sheet Metal Ductwork.

IP Model Code of Safe Practice: Part 1: Electrical (5th edition) 1995

List of Other Documents Applicable to HVAC (not referenced in this RP)

BS EN ISO 7235: Acoustic - Measurement Procedure for Ducted Silencers -
1996 Insertion Loss, Flow Noise and Total Pressure Loss

BS EN ISO 7730: Moderate Thermal Environments - Determination of the PMV and PPD
1995 Indices and Specification of the Conditions for Thermal Comfort

ISO 10816-1:1995 (=BS 7854: Part 1: 1996)
Mechanical Vibration - Evaluation of Machine Vibration by
Measurement on Non-Rotating Parts. General Guidelines.

BS EN ISO 14001: Environmental Management Systems. Specification with Guidance for
1996 Use.

IEC 79 - 0 Electrical Apparatus for Explosive Gas Atmospheres. Part 0:
General Requirements.

IEC 79 - 10 Electrical Apparatus for Explosive Gas Atmospheres. Part 10:
Classification of Hazardous Areas



NFPA (1996)	National Fire Prevention Association (USA). Codes of Practice.
BS EN 1057: 1996	Copper and Copper Alloys - Seamless, Round Copper Tubes for Water and Gas in Sanitary and Heating Applications
Institute of Petroleum	Model Code of Safe Practice Part 15: Area Classification Code for Petroleum Installations (1995)
API RP 500 (1991)	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities.
ASHRAE (1997)	Handbooks (F, A & E)
API Publ 4589 (1993)	Fugitive Hydrocarbon Emissions from Oil and Gas Production Operations
NS 5575 (1987)	Ventilation Ducts - Identification Colours.



TYPICAL EQUIPMENT DATA SHEET

As a minimum, Data Sheets should include the following information as appropriate.

Unit	Data
Type:	
Equipment No:	
Function:	
Duty:	:Flow Rate m ³ /s
	: Heating kW
	: Cooling kW
Heat Transfer Medium	: (Type)
	: Flow rate m ³ /s
	: Heating kW
	: Cooling kW
Pressure Entering	
Pressure Drop	
Design Pressure	bar
Test Pressure	bar
Operating Speed	rpm
Electrical Power	kW
Electrical Supply	Volts, Amps, Frequency (Hertz)
Noise Emission	Decibels
Heat Emission	kW
Utilities Requirements	Water, Compressed Air, Drains
Physical Dimensions	
Weight	kg

Data sheets should be prepared for all equipment items and for integral components forming part of the equipment.



DESIGN QUESTIONNAIRE

In addition to addressing the factors referenced in Section 2 'Design Requirements', the design contractor shall obtain at the outset of design for each building or enclosure sufficient information to complete the following 'Design Questionnaire'.

1. Internal Environment

Summer	- nominal dry bulb temperature	°C
	- relative humidity	% rh
	- acceptable range	+ or - °C
		+ or - % rh
Winter	- minimum dry bulb temperature	°C
	- minimum relative humidity	% rh

2. External environment

Summer	- design dry bulb temperature	°C
	- design wet bulb temperature	°C
Winter	- minimum dry bulb temperature	°C

3. Background Information

Tick as applicable, provide specific data as appropriate.

CLIMATE		LOCATION		EXPOSURE		CLASSIFICATION	
Arctic		Country		Sheltered		Non-Hazardous	
Temperature		Latitude		(City, town)		(Safe)	
Arid		Altitude		Exposed		Hazardous	
Tropical		Inland		(Open land)		Zone 0	
		Coastal		Prevailing Wind:		Zone 1	
				Direction		Zone 2	
				Speed			

Building Orientation - Relative to north



4. Internal Heat Gains - Refer to CIBSE Guide Book A7 for Data.

(a) Occupancy

Tick as applicable, provide specific data as appropriate.

BUILDING /AREA /ROOM	USAGE	NUMBER OF PEOPLE	ACTIVITY/WORK		
			SEDENTARY	LIGHT	HEAVY
	Continuous Intermittent Infrequent				

(b) Lighting

Tick, provide specific data as appropriate.

ROOM /AREA	ILLUMINANCE LUX	LIGHT FIXTURES		RATED OUTPUT PER UNIT W	INSTALLED POWER W/m ²
		TYPE	NO OFF		
		Fluorescent - Industrial Trough - Enclosed Surface Mounted - Enclosed Recessed Incandescent Opal Sphere High Pressure Mercury High Pressure Sodium			

(c) Equipment

Tick, provide specific data as appropriate.

ITEM	NO OFF	RATED OUTPUT kW	USE		
			CONTINUOUS	FREQUENT	INTERMITTENT
Computers Office Machines Cooking Appliances Process Equipment Motors					

Each separate equipment item in each building should be considered individually; for cooking appliances both sensible and latent heat emissions must be considered.

5. Fabric Heat Gain and Losses - Refer to CIBSE Guide Book Sections A3 and A9

(a) Glazing

Tick, provide specific data as appropriate.

TYPE	SINGLE	DOUBLE	TRIPLE	INTERNAL BLINDS		AREA m ²	ORIENTATION N.S.E.W etc
				YES	NO		
Ordinary							
Plate							
Heat absorbing - bronze							
Heat reflecting - bronze							
Heat reflecting - gold							

(b) Structure

Tick, provide specific data as appropriate.

WALLS	AREA m ²	ORIENTATION N.S.E.W etc	CLASSIFICATION		INSULATED		FINISH	
			LIGHT- WEIGHT	HEAVY- WEIGHT	YES	NO	LIGHT	DARK
Brick - Single								
Brick - Cavity								
Concrete								
Concrete Pre Cast								
Steel Plate								
Other								

ROOF	AREA m ²	TYPE		CLASSIFICATION		INSULATED		FINISH	
		FLAT	PITCHED	LIGHT WEIGHT	HEAVY WEIGHT	YES	NO	LIGHT	DARK
Tiled									
Concrete									
Concrete Pre Cast									
Steel Plate									
Other									

FLOOR	AREA m ²	CLASSIFICATION		PERIMETER INSULATION		CARPETS	
		LIGHT WEIGHT	HEAVY WEIGHT	YES	NO	YES	NO
Ground intermediate							

6. Building / Facility Utilities Requirements

(a) General

Complete as applicable

SERVICE	AVAILABLE ON SITE			REQUIRED FOR DESIGN		
	FLOW RATE	PRESSURE	TEMPERATURE	FLOW RATE	PRESSURE	TEMPERATURE
Steam						
Hot Water						
Cold Water						
Plant Air						
Instrument Air						
Drains						

(b) Electrical

(b.1) Power kW Available on Site

Supply Volts Amps Frequency Hz

(b.2) Required for Design

Complete as applicable

SERVICE	POWER kw	VOLTS V	AMPS A	FREQUENCY Hz
Fans				
Compressors				
Cooling Towers				
Pumps				
Instruments				
Panels				
Others				



COMPLETION AND TEST SHEETS

E1. INDEX OF MECHANICAL COMPLETION SHEETS

HVAC	1	Dampers
	2	Filter Coalescer - Air Filter
	3	Cooling Coil
	4	Electric - L.T.H.W. Heater Battery
	5	Centrifugal - Mixed Flow Fan
	6	Humidifier
	7	A.H.U.
	8	Constant Volume Terminal Unit
	9	Ductwork
	10	Refrigeration Unit
	11	Split A/C Unit
	12	Pressurisation Unit
	13	Boiler
	14	Cooling Tower
	15	Pumps
	16	Twin Fan Extract Units

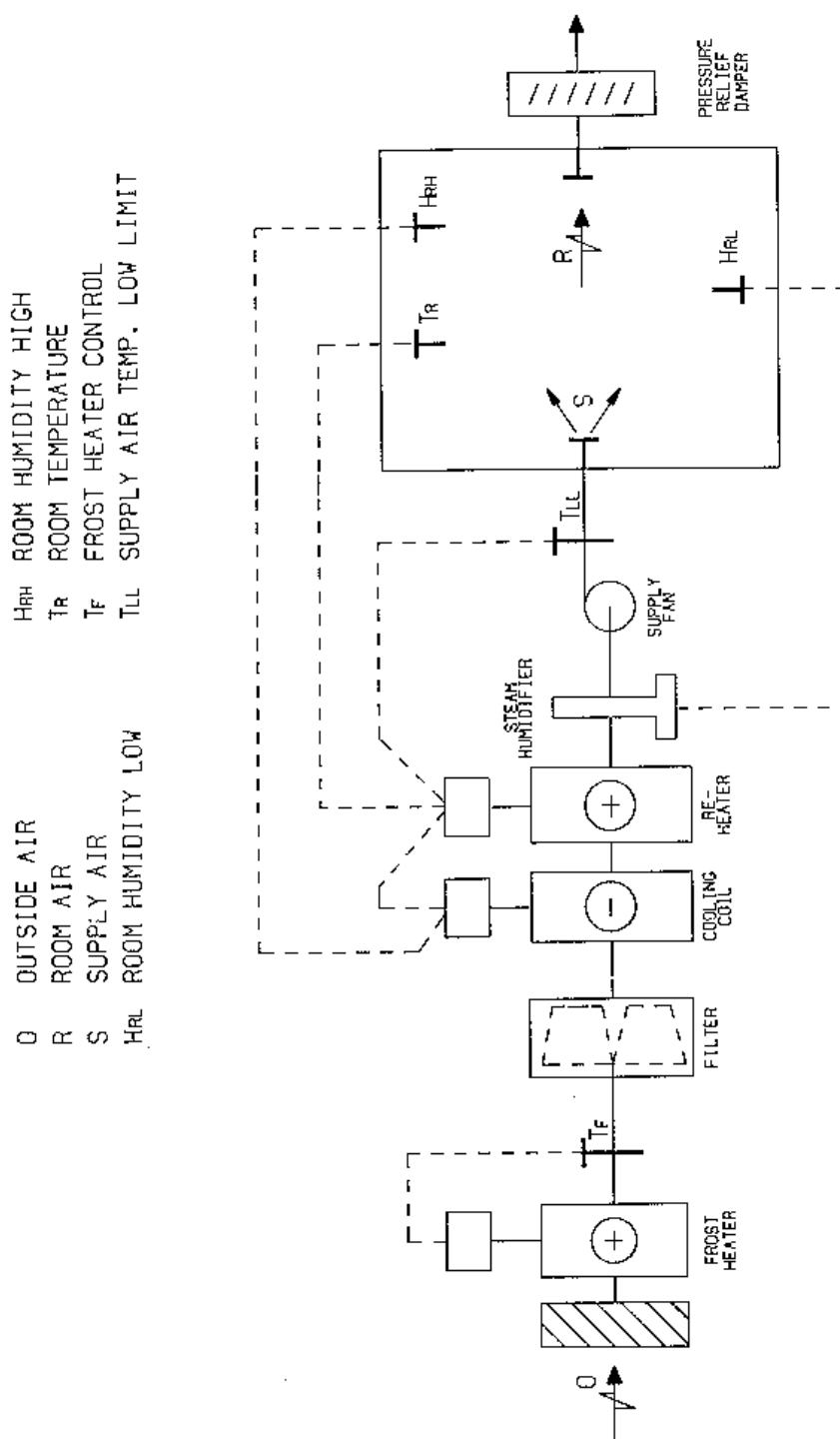
E2. INDEX OF TEST SHEETS

20	Instrument - Control Function
21	Dampers
22	Filters
23	Cooling Coils
24	Heaters
25	Fans
26	Humidifiers
27	A.H.U.
28	Ductwork Air Leakage
29	Terminal Unit
30	Grills/Diffusers
31	Refrigeration 1 of 2
	2 of 2
32	Split A/C Unit
33	Pressurisation Unit
34	Boiler
35	Cooling Tower
36	Pump
37	System Balance Sheet
38	Module Pressurisation

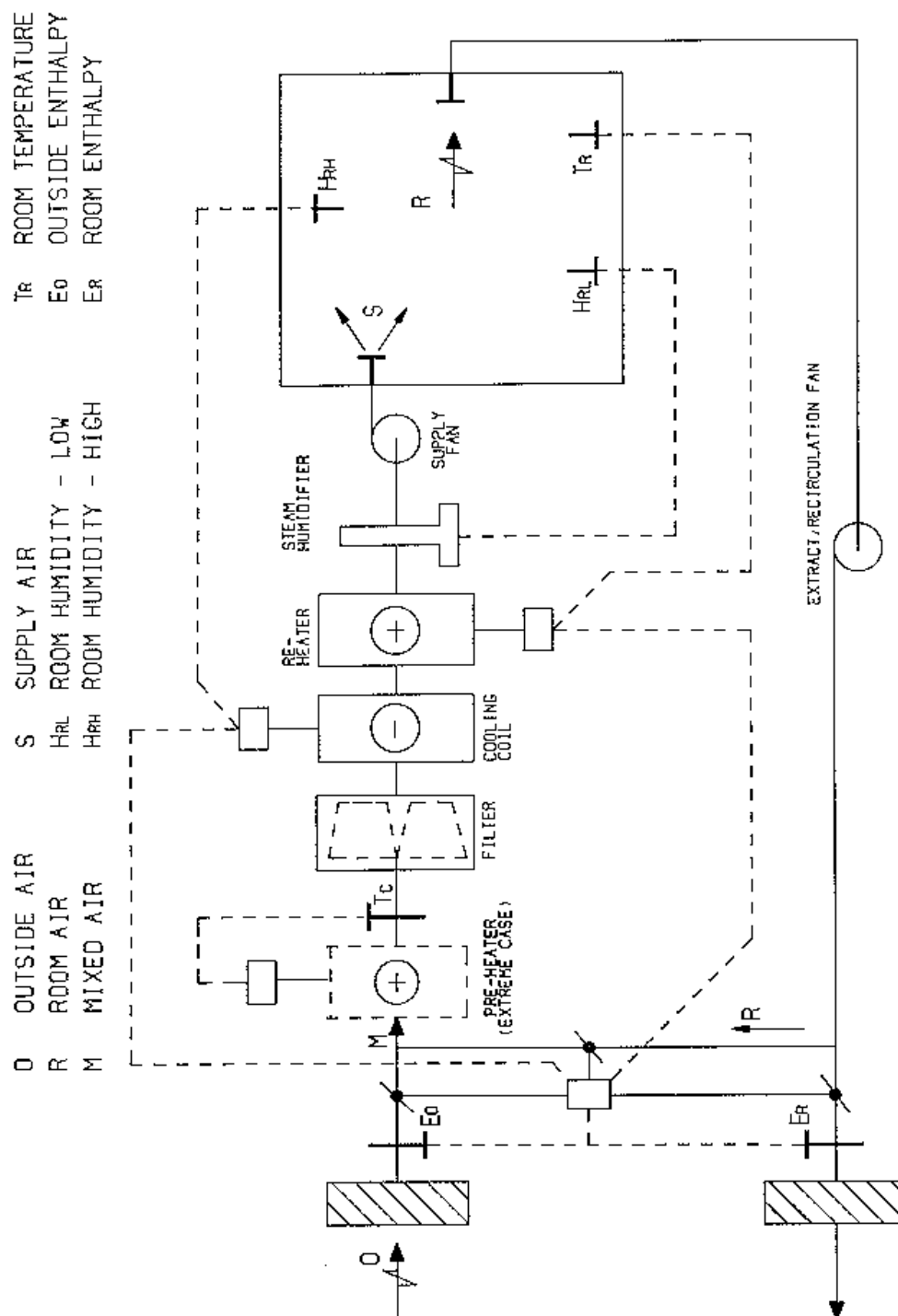


- 39 Pressurisation normal Operating Conditions
- 40 Smoke Test Procedure
- 41 Smoke Test of Pressurisation Area/Enclosure
- 42 Internal Conditions
- 43 Local Performance Check Sheet

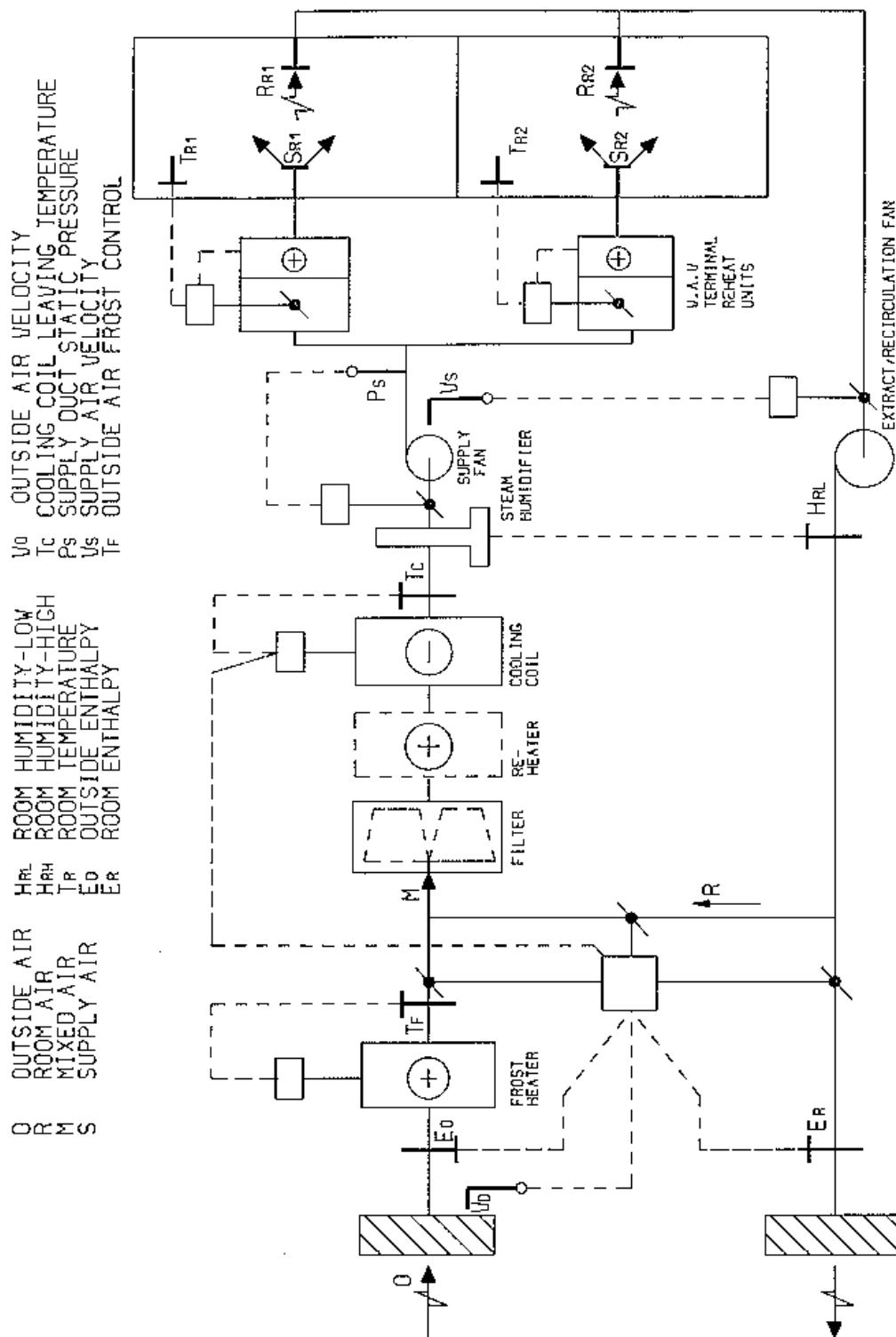




SINGLE ZONE - FULL FRESH AIR - SINGLE FAN DRAW THROUGH STEAM HUMIDIFICATION - SEQUENCE CONTROL WITH HUMIDITY OVERRIDE



**CONSTANT VOLUME SINGLE ZONE RECIRCULATION SEQUENCE
CONTROL WITH HUMIDITY OVERRIDE**



**VARIABLE VOLUME MULTIZONE RECIRCULATION WITH TERMINAL REHEAT
AND RESET ON TURNDOWN**