HEVAC GUIDE TO GOOD PRACTICE:
AIR HANDLING UNITS

HEVAC ASSOCIATION

HEVAC
AIR HANDLING UNIT GUIDE TO GOOD PRACTICE

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FOREWORD

Air handling units vary greatly in size, function and complexity. Whether they be small or large, simple or complex, there are certain points to observe and pitfalls to avoid. It is the aim of this publication to guide the reader towards good practice, so that when the unit is installed it will perform in accordance with expectations.

The components most commonly utilised within air handling units are dealt with individually and for each heading there has been gathered a list of 'do's and don'ts' distilled from many years of experience. Fans though are not covered specifically since there is a separate HEVAC 'Fan Application Guide' which should be referred to.

With such an immense variety within the scope of air handling units the topics covered cannot be completely comprehensive, however, the major and most important aspects are fully covered.

This publication was written by the members of the HEVAC Air Conditioning Group Technical Committee who devoted a considerable amount of personal knowledge and time to drafting the text.

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1. SELECTION OF AIR HANDLING UNITS

1.1. GENERAL

The requirements and constraints of the air handling unit (AHU) should be set out comprehensively by the specifier so that the supplier, in turn, has an unambiguous understanding of the design requirements. The supplier can then break down these requirements into the appropriate number of elements or sections of AHU which will include:

- The inlet into the AHU, often with dampers and the means of adjusting the balance between outside air and recirculated air
- The means of conditioning the air to achieve the specified comfort criteria
- The elements which determine the quality of the ventilation system in terms of filtration standards and noise spectrum
- The means of achieving the required mass flow of air and overcoming the flow resistance of both the unit and part or all of the external ventilation circuit

The principle questions that need to be answered in most AHU specifications are set out in the sections that follow. The coverage is not intended to be exhaustive, but provides a form of check list that will enable most factors which affect size, performance and cost to be communicated to the supplier.

1.2. TYPE OF CONSTRUCTION

Panel insulation should be specified in all cases where the AHU is delivering cooled or heated air and is indeed essential if condensation is to be avoided.

Note: Insulation is also essential for units mounted outdoors which are handling recirculated, heated or humidified air, if problems with internal condensation during winter are to be avoided.

Single skin panels may be less costly but double skin construction offers:

- Improved acoustic properties
- Resistance against erosion or physical damage of insulation
- Ease of cleaning

1.3. TYPE OF SYSTEM

These may be divided into the following headings:

a) **Single duct**
Constant volume
Variable volume with square law pressure relationship
Variable volume with constant duct pressure

b) **Dual duct**
Constant volume
Variable volume with square law pressure relationship
Variable volume with constant duct pressure

c) **Multizone**
Constant volume

Note: The type of system is a major factor in the fan drive selection

1.4. AHU ARRANGEMENTS

AHU arrangements should be stated in terms of:

- Limitations in size requiring delivery of unit in sections or broken into panels
- Location: internal or external, and the method of support

- Sequence of components, configuration of the unit sections and positions for maintenance access
- Direction of airflow: vertical up/down or horizontal

The above information may be best conveyed by a suitably detailed drawing.

1.5. DRAW-THROUGH OR BLOW-THROUGH

A 'draw-through' unit is one in which the air is drawn through by a fan section at the unit outlet. A 'blow-through' unit is one in which the air is blown through the coil section by a fan section positioned upstream.

Draw-through is normally adopted unless:

- High efficiency filters are installed as part of the unit, in which case they should be installed downstream of the fan to avoid ingress of unfiltered air
- The cooling coil has to remove the heat gain from the fan and motor in those cases where it is necessary to have the lowest possible supply air temperature
- The units are arranged as multizone or dual duct units

It should be noted that blow-through units have certain disadvantages. They increase the absorbed power, due to the higher pressure losses associated with discharging into a plenum as opposed to a duct. They increase the length of units due to the need for a uniform flow of air over the downstream components. Furthermore, the potential for air leakage is increased with the higher internal pressures on the fan discharge.

1.6. AIR HANDLING UNIT DAMPERS

AHU dampers are utilised for mixing and shut off, but are not recommended for the control of unit air volume because of their insensitive and inefficient control at low velocities and impingement of high velocity air on adjacent components when the dampers are nearly closed.

Air volumes and damper positions should be specified. Damper control should be stated: manual or motorised and the motor manufacturer if necessary.

1.7. FILTERS

The grade and type of filter should be specified, refer to the 'Filter Section' (p.6) for details of application.

The pressure drop will increase as the filter becomes dirty, but for fan selection a mid-value should be used. Specifying dirty filter pressure drop may lead to over-volume during commissioning.

1.8. HEATING AND COOLING COILS

The type of coil and full design conditions should be fully specified, together with the maximum air velocity to be adopted. The following list gives some items commonly overlooked and which may cause problems:

- It is insufficient just to specify a design load – it is also necessary to quote the air-on coil condition. For cooling coils the air-on coil condition should include humidity.
- Where glycol is to be used the % mixture must be stated.
- The refrigerant coil evaporating temperature, refrigerant type and number of circuits must be stated.

Note: Refer to the 'Coil Section' (p.15) for more details.

1.9. ELECTRIC HEATERS

It is normally more efficient to control the heater by switching it on and off in stages, specifying the number of steps to be adopted over the total power rating. Interlocks are required to prevent switching on without airflow and the method of interface should be indicated. Any special requirements for insulation should also be given.

1.10. HUMIDIFIERS

A number of humidifiers are available using either steam or water – see 'Humidifier Section'. If steam is to be used it is necessary to state whether it is from site mains or by generation locally. Also specify the efficiency required from the humidifier.

1.11. ACOUSTIC REQUIREMENTS

Specify any particular acoustic requirements, refer to 'Noise and Vibration Section'. This will dictate the minimum acoustic performance of the AHU casing.

Also, any special requirements for treatment of silencing materials should be stated, e.g. facing materials to withstand sterilising processes.

1.12. FANS

Determine all factors which may influence the choice of fan type (axial, centrifugal, or mixed flow) for example:

- Turn-down ration ie. ratio of maximum to minimum air volume
- Static pressure at full volume needed externally to the AHU
- Static pressure required at minimum volume flow, allowing especially for any constant pressure at terminal units
- Preferred means of varying fan duty: dampers, inlet vanes, variable pitch axial, variable speed with preference as to type of drive
- Minimum efficiency

Note: The above parameters will bias the choice of fan type, e.g. medium volume, high pressure, suggests backward curved centrifugal; high volume, medium pressure suggests axial. For VAV systems an axial fan with variable pitch impeller or centrifugal fan with variable speed control would be suggested.

Specify any special requirements for direct fan drives, external fan motors and standby motors. Any specific requirements for service factors should be stated, a minimum of 15% above motor rating is normal for belt driven fans to allow for small design variations. Also any power limitations should be stated.

1.13. OTHER ITEMS

Specify any other items where relevant, for example:

- Vibration levels at the mounting points
- Special packing requirements
- Storage requirements prior to installation
- Additional ancillary items such as control panels or refrigeration units

2. AIR FILTERS

2.1. GENERAL

Air filters are an essential component of every AHU. They serve many functions, the most basic being to prevent the clogging of heat exchangers and to minimise staining on walls and ceilings around supply air grilles. Filters can be designed to protect people by removing airborne infectious organisms within an operating theatre, or irritants within an office environment, such as tobacco smoke. They can stop contamination of food and pharmaceuticals, or protect sensitive processes such as micro-chip manufacture.

The physical sizes of the particles to be removed are so small that it needs a high powered optical microscope, or even an electron microscope, to make them individually visible. The unit of measurement used in air filtration is a millionth of a metre or micron. Tobacco smoke particles, for example, are only 0.3 microns in size. By comparison, the diameter of a human hair is typically 60 microns.

However, although the particles might be microscopic, they are present within the atmosphere in vast numbers. In a city environment there can be well over 300 million particles within a cubic metre of air.

2.2. FILTER CATEGORIES

Many different types of filter have been evolved to remove this contamination, each with its own applications, limitations, advantages and disadvantages. They can be very broadly grouped into three main categories:

1. Low efficiency or 'roughing' filters, for example:

- Disposable panel filters
- Filter pads
- Washable filters
- Automatic roll filters

2. Medium/High efficiency filters or secondary filters, for example:

- Bag filters
- Electrostatic filters
- Deep pleated filters

3. Ultra high efficiency filters or HEPA filters

Note: This category of filter is generally not recommended for AHU application

In addition there are specialised filters, e.g. carbon filters, which can be used within AHUs to deal with specific problems such as odour removal.

2.3. TEST STANDARDS

Two British Standards are commonly used to determine filter performance – BS 6540: Part I, which is appropriate for low, medium and high efficiency filters, and BS 3928 which is the test for ultra high efficiency filters.

Within BS 6540: Part I are two types of test. The first of these utilises a synthetic dust to determine the gravimetric efficiency – known as the 'arrestance' – of low efficiency filters and to establish the dust holding capacity of all filter types, low and high efficiency. The test dust is similar to typical atmospheric contamination, so the dust holding capacity provides an important guide for comparing the potential life of one filter against another. For medium and high efficiency filters the test makes use of outdoor air, and measures the ability of a filter to reduce the staining effect of the contamination in the atmosphere. This is reported in terms of an 'average efficiency' from clean to dirty.

The efficiency test, or atmospheric dust spot test as it is popularly known, is a more searching test than the gravimetric arrestance test. So a filter with an arrestance of 96% might have an average efficiency of only 30% using the atmospheric dust spot test method within BS 6540.

It is important to note that BS 6540 is identical to the European EUROVENT 4/5 Standard and the American AHSRAE 52-76, so a filter tested against all these methods should produce the same results.

BS 3928, which is the direct equivalent of EUROVENT 4/4, uses an artificially generated aerosol of 0.7 micron average diameter sodium chloride particles, to challenge the filter. The efficiency is measured using flame photometric techniques. Because of the small particle size it is a very severe test, and a filter whose average efficiency to BS 6540: Part I is 90%, if tested to BS 3928 could show an efficiency of only 70%.

The BS 3928 sodium flame test is a highly accurate method and is used routinely to individually test HEPA filters after manufacture to establish that they meet the specified acceptance level.

To summarise, three test methods are used – gravimetric, atmospheric dust spot (both to BS 6540) and sodium flame (BS 3928). Each method is appropriate to a particular band of efficiency.

2.4. FILTER GRADING PLAN – TABLE 1

To help classify filters EUROVENT have published a grading plan of 'EU ratings':

EUROVENT GRADE	ARRESTANCE to BS6540	AV. EFFY to BS6540	EFFY to BS3928
EU1	$A \leqslant 65$		
EU2	$65 < A \leqslant 80$		
EU3	$80 < A \leqslant 90$		
EU4	$A > 90$		
EU5		$40 < E \leqslant 60$	
EU6		$60 < E \leqslant 80$	
EU7		$80 < E \leqslant 90$	
EU8		$90 < E \leqslant 95$	
EU9		$E > 95$	
EU10			$95 < EI \leqslant 99.9$
EU11			$99.9 < EI \leqslant 99.97$
EU12			$99.97 < EI \leqslant 99.99$
EU13			$99.99 < EI \leqslant 99.999$
EU14			$EI > 99.999$

Where A is the arrestance
Where E is the average efficiency
Where EI is the initial efficiency

2.5. TYPICAL APPLICATIONS

As a very rough rule, the higher the filter efficiency, the higher the filter cost, the higher the operating resistance and the lower the dust holding capacity.

Filter efficiency is therefore probably the most important parameter used to determine which type of filter should be used for selection purposes. Different applications demand different levels of efficiency. For example, a roughing filter by itself would be totally inadequate for an AHU serving a hospital operating theatre. Conversely, a high efficiency filter would be completely inappropriate for a general factory area.

When high efficiency filtration is required it is usually cost effective to use more than one stage of filtration. For example, AHUs serving HEPA filters should be fitted with at least EU8 grade filters which should in turn be preceded by EU3 grade filters.

Overleaf is a list of typical applications with the suggested filter grades:

Application	Suggested EU Grade
General Factory Areas	EU2
General Office Areas	EU3
High Grade Office Areas	EU 6-7
Computer Rooms	EU 4-7
Hospital Wards	EU 6
Hospital Operating Theatres	EU 8-10
Retail Stores	EU 5-6
Food Factories	EU 6
Pharmaceutical Manufacturing Areas	EU 8-11
Restaurants	EU 5
Airport Terminal Buildings	EU 6
Libraries	EU 7
Leisure Centres, Swimming Pools	EU 5
Theatres, Concert Halls, Cinemas	EU 7
Hotels	EU 6
Exhibition Centres	EU 6
Museums, Art Galleries	EU 8
Schools	EU 5

2.6 SOME FILTER DO'S AND DON'TS

1. **DO** use roughing filters to prolong the life of expensive high efficiency filters.

2. **DO** provide a manometer across each filter bank to determine when the filters should be changed.

3. **DO** make sure that air cannot bypass the filters – a filter is only as good as its holding arrangement.

4. **DO** fit access doors and allow sufficient clearance to ease filter changing.

5. **DO** select filters carefully when variable air volumes are involved. The effectiveness of certain filters can be jeopardised by too low a face velocity.

6. **DO** look at dust holding capacity as a means of comparing filters.

7. **DO** provide weather louvres with screens.

8. **DON'T** fit HEPA filters within an AHU, but in terminal housing frames. If, however, they are fitted within the AHU they must always be located downstream of the fan section to prevent the inward leakage of unfiltered air which would result in loss of overall efficiency.

9. **DON'T** site filters too close to steam humidifiers or similar devices which may impinge water droplets onto the media.

10. **DON'T** overrate filters beyond the manufacturer's recommendations.

11. **DON'T** overlook the additional fan running cost incurred by high resistance filters.

12. **DON'T** allow the possibility of filters icing. Protect them, if necessary, with frost coils.

3. HUMIDIFIERS

3.1. GENERAL

The humidifier is a device installed to add moisture to an airstream in order to increase its relative humidity. Several types are available but in general the type selected will depend on:

- The rate at which moisture is to be added
- Availability of steam or suitably treated water
- Degree of control required over humidity within the conditioned space

There are three basic types of humidifier:

- **Evaporative** – where the air passes over water in thin film which provides a large surface area of water in contact with the air.
- **Atomising** – where water is mechanically broken up into minute droplets
- **Live steam** – where steam generated in some form of boiler, either remote or self contained, is actually injected into the airstream

3.2. EVAPORATIVE HUMIDIFIERS

There are two main types of evaporative humidifier. In one type water is pumped from a sump up into a header trough from where it flows down in a thin film over a porous mat or other infill through which the air passes. In an alternative type a drum or series of discs rotate partially submerged in a water bath. The air to be humidified passes over the wet upper section. These types of humidifier have relatively limited effectiveness and provide little control.

Great care has to be taken with respect to the water treatment and maintenance of this equipment to minimise the risk of bacterial infection.

3.3. ATOMISING HUMIDIFIERS

The atomising type of humidifier, as the name implies, causes the water to be broken up into minute droplets. In this form the injected water is absorbed into the airstream and it is therefore important to feed this type of humidifier with demineralised water in order to prevent the dissolved solids being circulated in the airstream as dust.

The water is atomised by using a spinning disc or alternatively by the generation of ultrasonic vibration.

3.4. STEAM HUMIDIFIERS

The live steam type of humidifier utilises purpose designed steam distribution headers located in the airstream. One design utilises an existing steam supply and is provided with a sophisticated system for control of the steam supply and condensate drainage. An alternative design is completely self contained with the steam generating boiler provided in a cabinet together with all controls. The steam generator can be of the electrode boiler or immersion heater type.

This type of humidifier can be used over a wide range of plant capacities and because of its sophisticated design is particularly suitable for close control applications. A less sophisticated design is a pan type humidifier located in the airstream.

3.5. SOME DO'S AND DON'TS

1. **DO** use demineralised water for atomising type humidifiers in order to minimise the maintenance requirements.

2. **DO** use suitable biocides/sterilising agents for recirculated water in order to minimise the risk of bacterial infection.

3. **DO** frequently and scrupulously clean and maintain the equipment, particularly sumps and wetted surfaces.

4. **DO** ensure that with the live steam type of humidifier, good condensate drainage is provided for the steam distribution header.

5. **DO** locate the humidistats sufficiently remote from the humidifier, where thorough mixing of the air has taken place.

6. **DON'T** allow a build-up of solids in evaporative type humidifiers. Control by means of blow-down or by using treated water, as appropriate.

7. **DON'T** locate filters, bends or obstructions where water droplets from atomising type humidifiers can cause precipitation. Consult the manufacturer for specific advice as to minimum distances.

8. **DON'T** attempt to humidify air having a high relative humidity e.g. air leaving a cooling coil.

4. VARIABLE DUTY FANS

4.1. GENERAL

For many AHU applications the ability to control airflow is necessary. Since there are many different means of controlling air flow the system designer should give careful consideration to all the options before making a choice.

Leaving aside the traditional use of dampers or bypass duct, there are three fundamental approaches to the variation of fan duty. These are:

- Control of the flow angle at the inlet of the fan, so affecting the aerodynamic performance of the impeller.
- Control of the impeller geometry. This includes the disc throttle in the case of centrifugal fans and the variable pitch impeller in the case of axial fans.
- Control of fan speed, either by means of some form of coupling between motor and impeller, or directly by adjustment of motor speed.

These options are shown in Figure 1, with an indication of their relative merits.
Since there are a number of other factors which influence the selection of a variable duty fan, these are discussed in the following paragraphs.

4.2. EFFECT OF TURN-DOWN RATIO

In many applications a range of volumetric flow from 100% to 50% is adequate. In this situation all of the methods shown are suitable. On the other hand, some applications require a greater range, even down to zero flow, and a screening of the options then leads to the following grouping:

Suitable Types	**Less Suitable Types**
Inverter Drive	Inlet Guide Vanes
Direct Current Motor Drive	Disc Throttle
Switched Reluctance Drive	Eddy Current Coupling
Mechanical Variable – Speed Coupling	Variable Voltage Control

4.3. EFFECT OF SYSTEM CHARACTERISTIC

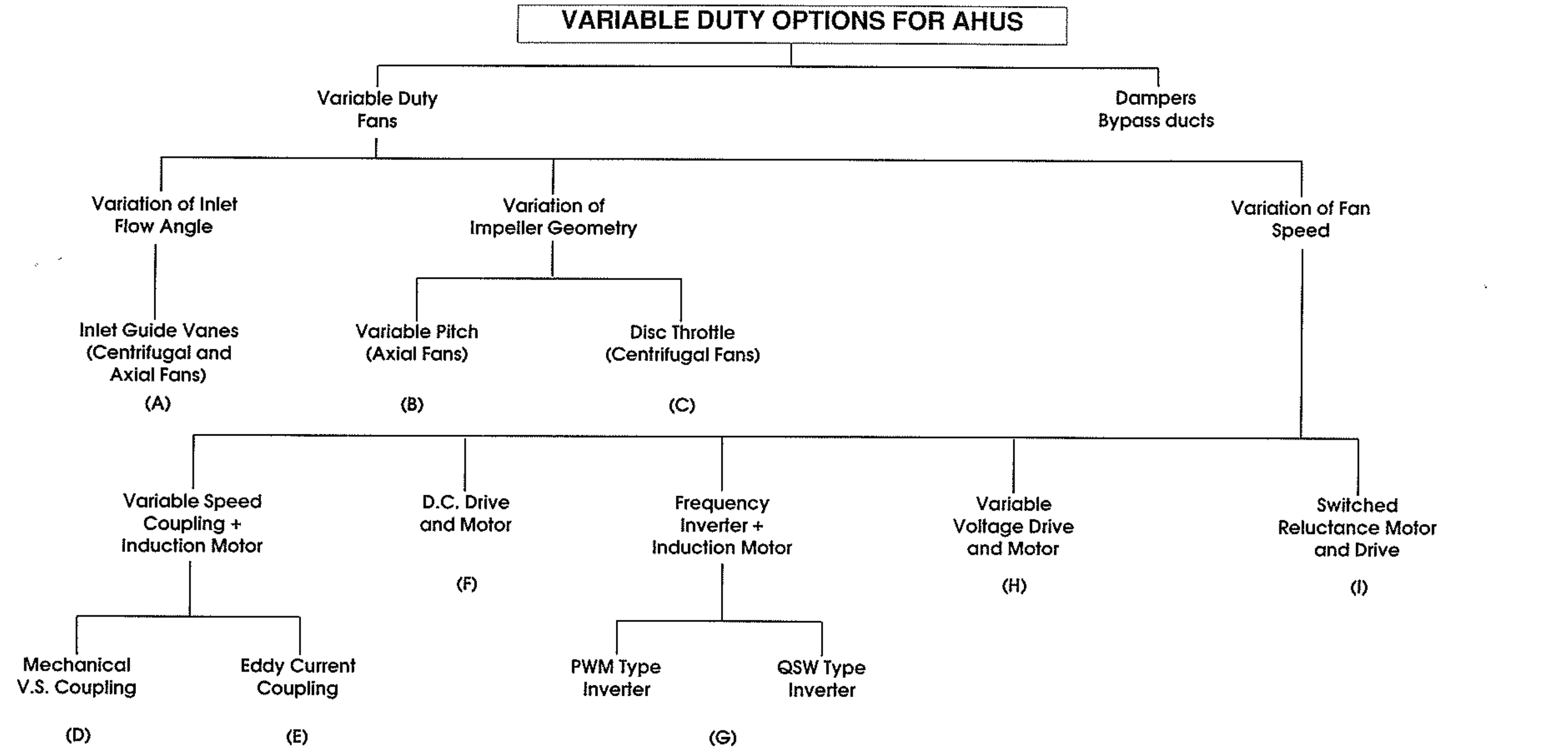
Most systems are a combination of a square law pressure-to-volume relationship and a constant pressure element. If the latter (usually associated with room terminal units) is a significant part of the combined characteristic there will be a limit to the turn-down ratio available from a variable speed fan – since this will have a simple square law relationship between pressure and speed. In such situations a variable duty fan that offers a more uniform pressure is preferable, e.g. a variable geometry fan or inlet guide vanes.

4.4. COST

A simple analysis which takes into account the likely duty cycle, total running hours per year and pay-back time is usually sufficient to compare the relative effects of capital and running costs. The calculation of running costs must allow for the effect of losses in the controller and any extra motor losses such as are associated with the non-sinusoidal supply from a frequency inverter. It should also cover the effect of maximum demand (kVA). The influence of maintenance costs should be included if comparative figures can be assessed, e.g. by obtaining the cost of maintenance contracts.

4.5. SPACE

If space is at a premium, this will influence the choice of fan type and the use of direct drive versus indirect drive for the fan. A variable speed coupling will tend to be less attractive as a result.



	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
Available Turn-Down Ratio	Limited	Unlimited	Good	Good	Limited	Unlimited	Unlimited	Good	Unlimited
Relative Capital Cost	Low	Medium	Med/High	High	Medium	High	Med/High	Medium	Med/High
Relative Running Cost Savings (for 2:1 turn-down ratio)	Low	High	Medium	Medium	Medium	High	High	Medium	High

FIG .1 COMPARISON OF VARIABLE DUTY OPTIONS

4.6. PEAK ELECTRICAL DEMAND

The influence on cost of maximum kVA demand will be only marginal between one system and another, but the fact that many frequency inverters present a near unity power factor load to the supply can be an advantage with some electricity tariffs, by reducing the amount of power factor correction that is required.

If operation at or near full duty is likely to be required much of the operational time, the overall efficiency of the variable duty fan plus controller becomes significant and in this context the extra losses with an inverter are a disadvantage compared with a variable geometry fan or even with inlet guide vanes.

4.7. VIBRATION AND NOISE

There can be an advantage in choosing a variable speed fan due to the inherent reduction in noise level as speed is reduced, e.g. for a low night time duty and a low NC rating requirement. It is an inescapable feature of all drives which supply a non-sinusoidal voltage to the motor that harmonic vibration or noise can be a problem. Particularly noticeable is the audible frequency associated with PWM inverters, or the resonant vibration that can occur at one or more regions within the operating range of speed. If service problems of this nature are to be avoided the manufacturer should be asked for his experience and advice concerning alternative variable speed drives.

4.8. STARTING LOADS

It is an inherent feature of most, if not all, electronically controlled drives (switched reluctance, inverter, variable voltage) that they provide a soft start, i.e. a limited current input while accelerating. This obviates the need for a separate, current limiting device, e.g. star-delta starter, but it can extend the starting times, especially with a high inertia impeller, to unusually long periods.

The variable geometry fan (particularly the variable pitch axial fan) also limits starting energy, but not the peak current, by its ability to be started at its condition of minimum airflow.

4.9. INFLUENCE OF SUPPLY AUTHORITIES ETC

As noted in paragraph 4.7., 'Vibration and Noise', those variable speed drives that distort the electrical waveform (inverters, switched reluctance and variable voltage drives) also draw harmonic currents from the supply. At the present time the UK authorities tolerate the level of low frequency harmonics associated with the usual range of AHU fan powers, but this situation could change in the future. The presence of these harmonics needs to be borne in mind if any such variable speed system is adopted, since effects on other nearby plant are possible (depending on the supply impedance), and Radio Frequency Interference is another possibility. The latter can usually be suppressed without great expense, but the lower frequency harmonics cannot be so easily dealt with, in the rare event that problems arise.

4.10. NOTES ON VARIABLE SPEED OPTIONS

No major developments have taken place in recent years in the design of variable speed couplings, and these continue to be manufactured in their mechanical and eddy current types.

There are now a large number of electronically-based drives available, but they can be grouped as follows:

- **Frequency Inverters:** *PWM type (PWM = pulse width modulated)*
  Now the most common, these rectify the mains supply and synthesise a 3-phase output, the frequency of which can usually be varied from near zero to twice mains frequency. The rapid switching provides an output that contains a number of harmonics, but the effect on motor efficiency is small, such that a de-rating of 10 to 20% is sufficient with fan loads.

- **Frequency Inverters:** *QSW type (QSW = quasi square wave)*
  Sometimes referred to as pulse amplitude modulated. Although similar in basic concept to PWM inverters, the frequencies of the harmonics in the output are quite different, and the effect on fans is to require a slightly greater de-rating (15 to 25%). The harmonic noise associated with the PWM type is usually absent, but vibration can be encountered at resonant frequencies, especially in some early designs.

- **Switched Reluctance Drives:** Whereas inverters are used in conjunction with standard induction motors, this system requires a matched reluctance motor and controller. A slightly higher efficiency is claimed for the system, and first cost tends to be less, compared with inverter drive systems. Harmonic noise is still a feature of the switching arrangements adopted, as with PWM inverters.

IMPORTANT NOTE:

All of the above variable speed drives have the advantage of being able to increase the speed of the motor above its normal design value. In the case of inverters, which may not be matched to the motor design, it is very important that the frequency is not boosted without reference to the AHU manufacturer, otherwise rapid motor overheating due to overload can occur.

Some of the drives available offer a control arrangement particularly suited to fans and pumps, whereby the voltage to the motor is varied such as to minimise the current taken. This type of characteristic is advocated in comparison with others that provide only a fixed voltage-to-frequency relationship.

- **Variable Voltage Drives:** A lower first cost, but lower efficiency system, this can be used for up to about 10kW in directly driven fans, and to 100kW or more with belt driven fans. The motor has to be a special form of induction motor, greatly de-rated because of the increased heat dissipated within it. Frequency boost is not available, and some increased harmonic noise is likely to be apparent.

The above groups do not include all possible types of electronically-controlled variable speed drives, but the majority of those currently marketed for use with fans fall within one or other of them.

4.11. SOME DO'S AND DON'TS

1. **DO** make sure an assessment of the likely duty range is made to ensure the type of variable duty fan selected is suitable.

2. **DO** ensure the operating hours per annum are known and running costs predicted as realistically as possible.

3. **DO** define fully the controls interfaces, and ensure the controls supplier checks that there will be no compatibility problems.

4. **DO** ensure the AHU supplier and the fan manufacturer are aware if it is intended to include a frequency inverter, by separate contract, for fan duty control.

5. **DO** ensure that if an inverter is to be specified then the frequency cannot be raised above that of the supply without checking that the ventilation system will not be damaged by excess pressure or fan motor overload.

6. **DON'T** specify a system which is beyond the competence of normally available staff to maintain.

7. **DON'T** forget to check whether any special requirements are imposed by the supply authority regarding harmonic disturbance or starting current, which may influence the choice of fan duty control equipment.

5. COILS

5.1. GENERAL

The heat exchangers in AHUs are usually of the fin and tube type, commonly referred to as coils. In most instances the coil comprises aluminium fins, continuous over the height and depth of the heat exchanger, spaced along copper tubes. To meet arduous conditions alternative materials such as vinyl coated aluminium fins, copper fins, electro-tinned copper fins/tubes may be considered. Coils for steam heating often feature steel.

The tubes are put into a 'stack' or 'block' of fins and expanded to achieve good thermal contact with the fin collars. The tubes are circuited to provide contra flow, optimised heat transfer and acceptable pressure drop.

Common arrangements are one or two rows for heating and four to six rows for cooling coils. Deeper coils may be appropriate for heat recovery. Fine tuning of surface area, to minimise costs, can be achieved by adjusting the fin pitch.

The face area of the coil (height x finned length) is determined by the physical constraints of the AHU airway in which it is to fit but is also subject to velocity considerations. In all cases this will affect the airside pressure drop, but in the case of cooling coils, excessive velocity will carry condensate droplets from the fin surface and deposit them downstream. The limiting velocity will depend on coil design and application and will normally be 3m/s or less.

5.2. FRESH AIR

- Adequate frost protection must be provided for heating coils handling fresh air, to ensure that full heating medium is at the coil when the air temperature falls below 1.5°C. Airflow must be delayed until the coil has reached full temperature e.g. condensate purged etc, also fans must be shut down before the heating medium.
- Fresh and recirculated air must be thoroughly mixed before the coil, especially if control valves are fitted.
- Fit pre-heaters before coolers if the temperature can ever fall below 5°C. Otherwise add antifreeze to the chilled water or drain down during the winter period.
- Do not use throttling valves on steam or water coils in the presence of air at sub-freezing temperatures.

5.3. COOLING COILS

- Correct trapping of condensate drain lines is paramount, failure to observe this will result in flooding. Refer to Section 9.5. for details.
- Airflow should be evenly distributed over the complete face area, especially with Direct Expansion coils.
- Moisture carryover must be considered when air velocities are above 2-3m/s, depending on the coil configuration and rate of moisture extraction. Whilst eliminators allow a marginal increase in air velocity, they incur a pressure drop penalty.
- The pipework to and from chilled water coils should allow for adequate venting and draining of the coils and piping.

5.4. HOT WATER COILS

- Care must be taken to ensure that pipework allows free expansion of headers and tubes, especially with HPHW.
- The pipework to and from coils should allow for adequate venting and draining of the coils and piping.

5.5. STEAM COILS

- Traps should be of constant discharge type e.g. float and thermostatic or bucket type. Temperature controlled traps are not recommended.
- For best results fit one trap per condensate connection. Coils banked in series MUST be separately trapped.
- If control valves are fitted the condensate must have a free fall back to the receiver. If a condensate lift is unavoidable a condensate pumping set should be fitted.
- Steam mains should be adequately trapped and vented prior to connection to coil.
- When coil sections are installed for series airflow and modulating control is used, each coil bank must be controlled separately.
- Face and bypass is the best method of control to avoid condensate hold up with its associated problems.
- A vacuum break must be fitted when using control valves.
- See Appendix 'A' (p.30) showing recommended trapping arrangements.
- Care must be taken to ensure that pipework allows free expansion of headers and tubes.

5.6. PRE-COMMISSIONING

- Remove all protective covering.
- Check frost protection and drain down if heat is not available during freezing conditions, especially after pressure testing.
- Where chemical cleaning/sterilising is to be carried out check that the chemicals are compatible with all the materials used throughout the system.
- Check that the fins are straight. Bent or damaged fins can be straightened with a fin comb or a pair of long nosed flat pliers.

5.7. SOME DO'S AND DON'TS

1. **DO** correctly trap cooling coil condensate drains or flooding may result.
2. **DO** adequately trap steam condensate drains otherwise water hammer or freezing is likely to occur.
3. **DO** avoid the possibility of moisture carryover from the fin blocks of cooling coils, by limiting the maximum face velocity (in preference to fitting eliminators).
4. **DO** protect finned coils from dirt build up by fitting filters upstream of them.
5. **DO** specify sufficient space for access to both faces of each coil for inspection and maintenance.
6. **DO** allow for free expansion, especially in the case of steam and HPHW coils.
7. **DON'T** modulate frost coils.
8. **DON'T** allow the weight of piping and valves to be taken by the coil connections.
9. **DON'T** forget to include measures to prevent the freezing of water coils during cold weather, especially during shutdown periods.

6. GAS FIRED UNITS

6.1 GENERAL

Gas fired units can provide a relatively simple, cheap means of heating air. By burning the gas within the AHU the role of boiler plant is reduced to providing only domestic hot water. This not only saves on the cost of boilers and their ancillaries such as piping, valves and pumps but also on the cost of the plantroom itself. Indeed, gas fired AHUs are often roof mounted to completely eliminate the need for conventional plantrooms.

Gas fired units are therefore becoming increasingly popular for factories, warehouses, supermarkets, shopping centres, exhibition halls and particularly for make-up air applications such as car painting plants.

6.2. DIRECT AND INDIRECT

There are two basic types of gas fired heater modules used within AHUs – direct and indirect.

Direct gas fired modules, as the term implies, burn the gas directly in the airstream. Because the heat is added direct, efficiencies up to 98% based on nett calorific value are obtainable. It follows that the products of combustion, albeit highly diluted, are supplied to the space being heated.

Indirect heaters utilise a sealed combustion chamber connected to a sealed tubular heat exchanger over which the airstream is passed. The products of combustion are separately vented to atmosphere via a flue and hence do not mix with the supply air. Their operating efficiency is typically in the order of 75%.

Because the products of combustion are added to the airstream, care has to be taken with the application of direct fired units. The concentrations of oxides of carbon and nitrogen and the concentration of aldehydes in their discharge air are all limited by BS 5990 to ensure that the concentrations within the space do not exceed permitted threshold limit values for health. In the case of AHUs the air temperature rise across the burner section typically is less than 40°C, so the quantity of air passed through the unit is considerably more than necessary for combustion and the products of combustion are therefore greatly diluted. Hence it is possible to recirculate the air. Depending upon the dilution rate, up to 75% recirculation is possible; the lower the temperature rise the higher the permissible recirculation rate. Arrangements for recirculation should always be fail-safe to ensure that the maximum levels cannot be exceeded.

Care must be taken with both types of burner where there is a potential risk from flammable vapours or dusty atmospheres e.g. flour mills. In applications where flammable vapours may be present in excess of their threshold limit values all combustion air supplied to the unit must be fresh air, hence ruling out recirculation in the case of direct gas fired units. Although heaters must not be installed in hazardous areas, they can be used for applications such as workshops, laboratories and garages where the normal concentrations of flammable vapours are below the threshold limit values.

6.3. CONTROLS

The controls supplied as part of the AHU can vary between the minimum required to control the safety of the gas fired module, to a full, automatic controls package incorporating supply fan starters, damper motors, timers, interlocks and temperature sensors. It is therefore important that the specifier and manufacturer agree on what is to be supplied as part of the AHU and what is the responsibility of the controls sub-contractor.

The minimum supply will consist of:

- A system (normally incorporating a pressure switch) for proving adequate combustion airflow during the pre-purge, ignition and operation of the burner. Airflow failure has to cause safety shutdown. In addition, the air proving device has to be proved itself to be in the 'no-air' position prior to start up. Failure to prove 'no-air' has to prevent start up or cause lock-out.
- A flame supervision system to provide safety shutdown or lock-out if there is a flame present during pre-purge or if there is a flame failure. The system also has to monitor both the start gas and main flame establishment, providing lock-out if the timed conditions are not met.
- An overheat thermostat to protect the equipment.

In addition to the above minimum which would always be supplied as part of the burner module there has to be provided:

- For indirect burners, a timing device to ensure the supply fan over-runs once the burner is switched off, to prevent damage from the residual heat within the module.
- A supply fan interlock to prevent the burner controls being energised whilst the supply fan is switched off.
- A thermostat for controlling the temperature during normal running conditions.
- Supply fan starter, damper motors, etc, normally associated with AHUs.

Other control items available include:

- Timers for automatically bringing the plant on and shutting it down.
- Low gas pressure and high gas pressure safety switches.
- Low temperature sensor, to switch the burner off at minimum heat conditions.

Burners can be On/Off, Hi/Lo/Off and fully modulating. Turn-down ratios of up to 40:1 are available in the case of direct gas fired units, but indirect fired burners have turn-down ratios of 10:1 or less. When the supply fan is two speed or variable air volume the controls must be designed to avoid high air temperatures at low speed. This is simply done by mounting an override thermostat in the supply duct.

6.4. SOME DO'S AND DON'TS

1. **DO** specify who is responsible for the total controls package – the AHU manufacturer or the controls sub-contractor.
2. **DO** ensure that the burner is interlocked with the supply fan.
3. **DO** ensure that a viewing panel is provided to watch the operation of the burner whilst the fan is running.
4. **DO** make sure that the burner manufacturer is made aware of the gas pressure at the enquiry stage, as this can affect the performance and hence selection of the burner.
5. **DO** ascertain that the type of burner is suitable for the application.
6. **DO** insist that the burner installation complies with the appropriate British Standards – BS 5990 (Direct), BS 5991 (Indirect) and BS 6230.
7. **DO** provide a clearly marked, easily accessible stop valve immediately adjacent to the unit.
8. **DO** take care with locating other sections to avoid risk of damage from high temperatures or high velocities.
9. **DON'T** attempt to commission a unit without specialist help, as incorrect or incomplete commissioning can be potentially hazardous.
10. **DON'T** mount flues of indirect burners in a location where they can be susceptible to downdraughts.
11. **DON'T** mount extract grilles close to supply air grilles so as to cause unintentional recirculation.
12. **DON'T** neglect maintenance.

7. NOISE AND VIBRATION

7.1 GENERAL

The fan is the primary source of noise within an AHU. The Fan Manufacturers' Association's 'Guide to Fan Noise and Vibration' should therefore be used in conjunction with the recommendations that follow, as should British Standard BS 848: Part 2.

7.2. NOISE DUE TO AIR FLOW

The various components that are installed within an AHU can either regenerate or absorb noise. The noise due to air flow is a result of turbulence generated by louvre blades, turning vanes, changes in section, obstructions and even attenuator splitter packs.

When sizing intake louvres and dampers, the higher the air velocity the greater their tendency to generate noise. Furthermore, high velocities carry a risk of resonant vibration of vanes that have low stiffness. In general, maximum velocities recommended by the manufacturer should not be exceeded.

Attention should also be given to the inlet dampers, providing an air flow which is relatively even, without high peak velocities due to poor configuration of ductwork onto the inlet of the AHU.

Those components that have an insertion loss such as filters and coils must be applied at the correct air velocities within the section. Otherwise there is a danger that the components' insertion loss may be exceeded by regenerative noise.

7.3. AIR LEAKAGE

Air leakage from the unit is a source of noise leakage, so it is essential that the leakage of any AHU be within the recommendation of the HEVAC Association's 'Guide to AHU Leakage Testing'.

7.4. SPECIFIED NOISE LEVELS

The noise level required in the space or plantroom can only be determined by the customer.

The AHU manufacturer will be able to specify the sound power levels at the inlet and outlet of the AHU, and the breakout noise level.

It is the customer's responsibility to use this information correctly to determine the resultant sound levels in the area served and to the outside environment.

It is not feasible to state that an AHU is to give a specified NC or NR level, as the design of ductwork, the room characteristics and all the other factors which affect noise levels are not known to the AHU manufacturer.

7.5. COMPATIBILITY OF DUCTWORK

Whilst the breakout sound power level and inlet/outlet sound power levels can be provided by the AHU manufacturer, it is important that the relative location of the AHU and associated ductwork be assessed. For example, when a unit has built in attenuators, due consideration must be given to casing breakout noise which can flank the attenuators.

7.6. VIBRATION

All rotating machinery has out of balance forces. Therefore it is usual to employ anti-vibration mountings and flexible connections to reduce the transmission of vibration to the surrounding structure.

7.6.1. Location of AV Mountings

AV mountings can be located as follows:

- Internally, directly under the fan/motor assembly, or –
- Externally, under the whole unit or under the fan section only, provided it is isolated by flexible connections at the inlet and outlet to the fan section.

However, when mounting a unit on external mountings, internal mountings should not be placed under the fan/motor assembly, as resonance may result.

7.6.2. Type of Mountings

The most common types of AV Mountings used are:

- Rubber in shear, which are relatively stiff.
- Spring coil mountings, which are relatively soft.

The type of mount to be selected depends on the isolation goals to be achieved. Furthermore, the actual selection must relate to the whole system, AHU and structure.

7.6.3. Floating Floor/Inertia Bases

Floating floors are used to improve the noise and vibration insulation of light weight structures and are, of course, simple mass spring systems. However, when an AHU is installed on a floating floor system/inertia base, the advice of a Vibration Consultant is recommended.

7.6.4. Induced Vibration Problems

All connections to and from an AHU, e.g. pipework, ductwork, cabling etc. must be via flexible connections to reduce vibration transfer problems.
When a unit is mounted on external AV mounts it is essential that the unit is not used as a structural support for other plant, in order that the AV mountings operate correctly within their weight limits.

7.7. SOME DO'S AND DON'TS

1. **DO** ask for specialist advice if an AHU is being mounted on a lightweight structure.

2. **DO** avoid excessive velocities over turning vanes, louvre blades etc., which can lead to regenerated noise.

3. **DO** check that AVMs and flexible connections are all working freely and effectively.

4. **DON'T** mount silencers close to fan outlets, as this can affect their dynamic performance.

5. **DON'T** specify noise levels any lower than are really necessary.

6. **DON'T** overlook the potential effect of locating noisy equipment, such as pumps and compressors, in the vicinity of the air inlet to an AHU.

7. **DON'T** overlook the potential nuisance from unsilenced air inlets and outlets.

8. **DON'T** forget to check that any transit bolts have been removed before the AHU is first run.

9. **DON'T** allow, in the case of units with external AVMs, any flanking by rigid pipe or cable connections.

10. **DON'T** mount AHUs in sensitive locations such as above false ceilings over auditoria unless full consideration has been given to noise breakout.

8. LOCAL SYSTEM EFFECTS

8.1 GENERAL

AHUs when tested on site often do not meet the required performance, even though correctly rated by tests in accordance with BS 6583, 'Volumetric testing for rating of fan sections in central station AHUs'. The usual reason for this is the local system effect on the performance of the units.

The fan section of an AHU is always rated under laboratory conditions, with ideal air flow conditions upstream and downstream. it is not always possible to provide these within the restrictions set by available installation space. It should therefore be realised that deviations from ideal conditions produce losses, which if not allowed for will affect the whole performance of the unit.

The purpose of this section of the guide is to explain what happens when AHUs are connected to non-ideal systems, and the effect the various physical arrangements have on the unit's performance.

Units with fans of different types, and even with fans of the same type but supplied by different manufacturers, will not necessarily react with the system in exactly the same way.

8.2 AIR HANDLING UNIT FAN SECTION PERFORMANCE

AHUs should be tested and rated in accordance with BS 6583, which defines exactly the procedures and conditions to be used. This enables ratings published by different manufacturers to be properly compared. The units tested to BS 6583 are fitted with a long outlet test duct to ensure that air flow at the plane of measurement is as uniform as possible. Figure 2 (p.22), shows typical arrangements which are based on BS 848. The angle of transition between the test duct and the fan section outlet is also limited to ensure uniform flow is maintained.

Uniform air flow conditions help to ensure consistency and repeatability of test results and permit the AHU to operate efficiently. In any installation where these conditions do not exist the performance may be reduced.

8.3. AIR SYSTEMS

The air system consists of a network of ducting and duct fittings including attenuators, terminal boxes, grilles, diffusers and so on, through which the AHU supplies air to the controlled space.

The way in which the AHU is physically connected to the system may introduce additional losses which must be taken into account during the design stage. These can be assessed using the 'Local System Effect' factors.

8.4 SYSTEM CHARACTERISTICS

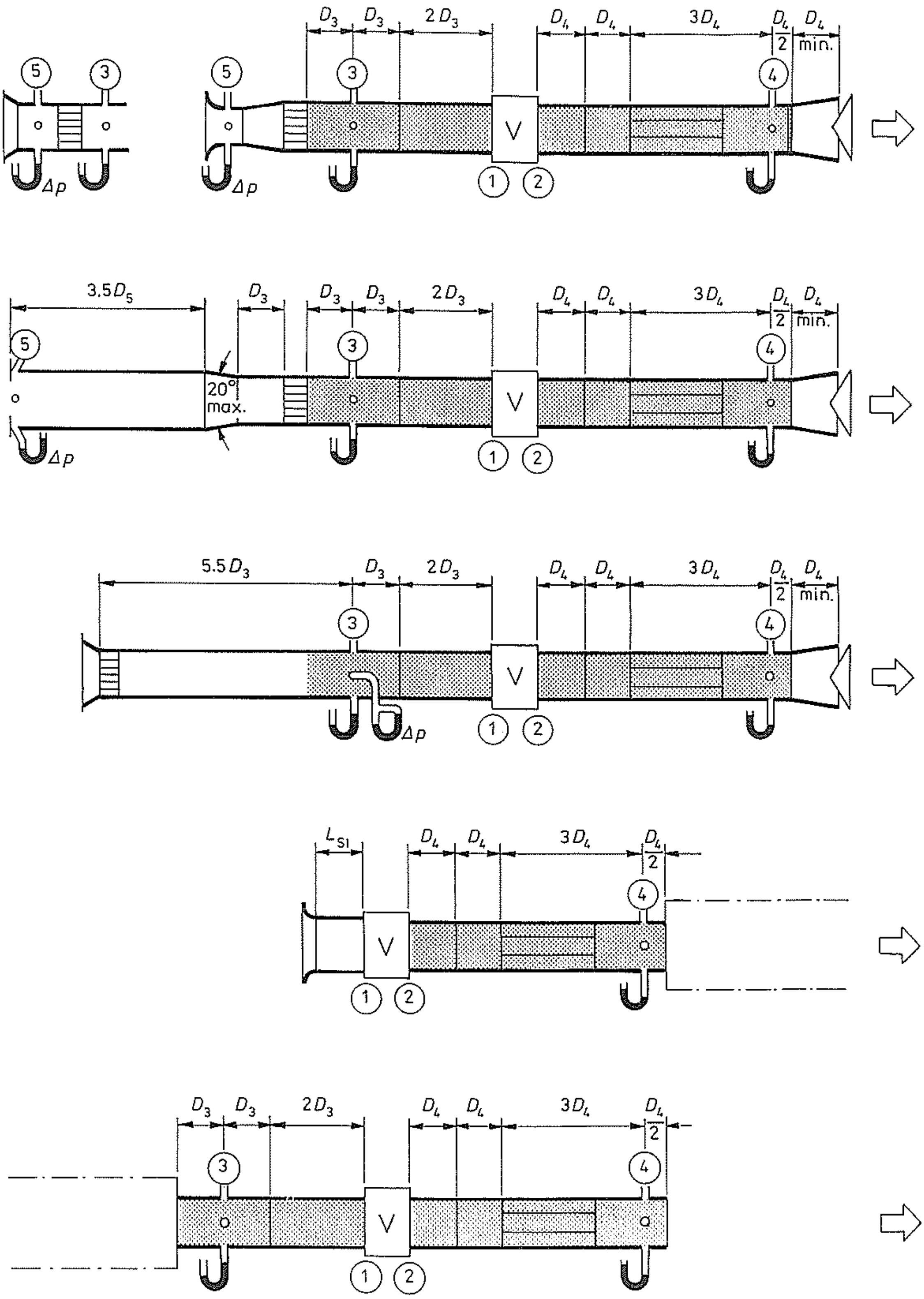
At a given volumetric flow through a known air system a corresponding pressure loss or resistance to this flow will exist. If the flow rate is changed the pressure loss or resistance to flow will also change. The relationship governing this change for most systems is:

$$\frac{\text{Pressure 1}}{\text{Pressure 2}} = \left(\frac{\text{Flow 1}}{\text{Flow 2}}\right)^2$$

The AHU fan section has also to overcome the resistance of other components within the unit, e.g. filters, coils, dampers, etc. The relationship of resistance to flow similarly follows the square law.

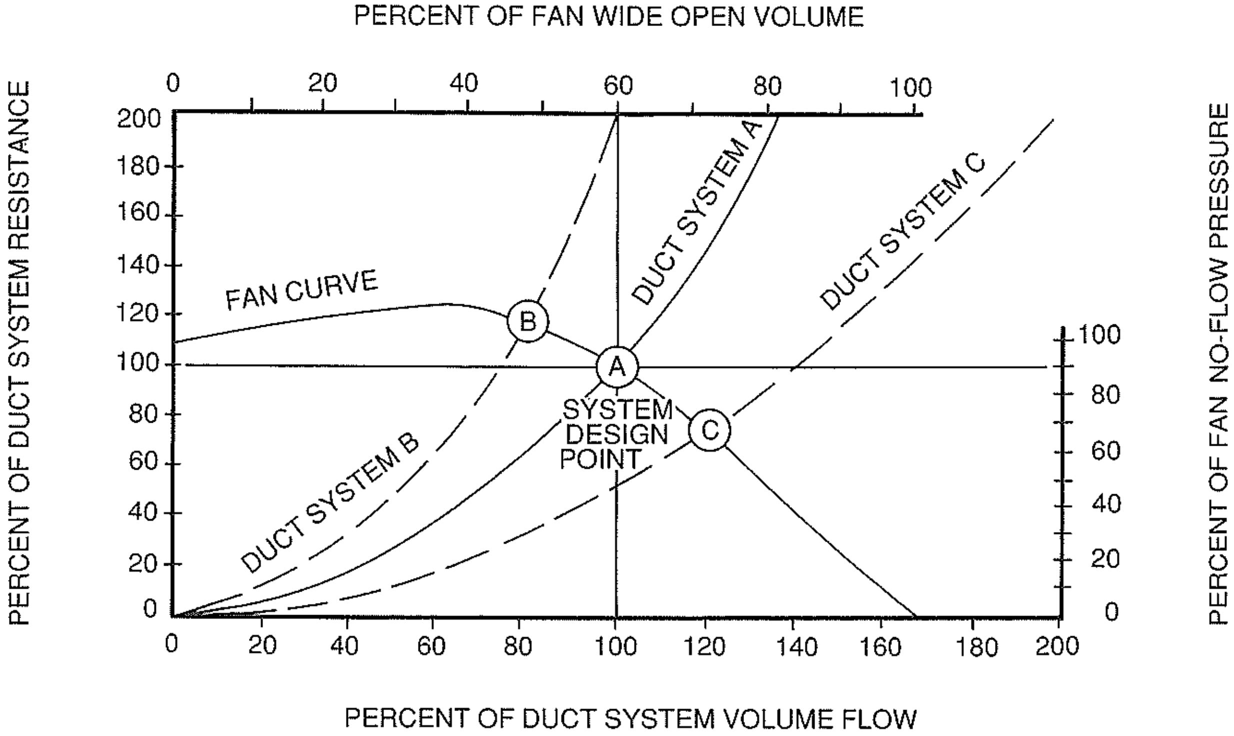
The system resistance and AHU internal resistance together form a combined resistance which the fan section has to overcome. The characteristic of these plots a parabola. Curve 'A' of Figure 3 is a typical plot of resistance against volumetric flow, where it intersects with the fan characteristic curve, point 'A', will be the design operating point.

FIG.2 TYPICAL AIRFLOW MEASUREMENT ARRANGEMENTS



Extracts from BS 848 : Part 1 : 1980 are reproduced with the permission of BSI.

FIG. 3 INTERACTION OF SYSTEM CURVES AND FAN CURVE

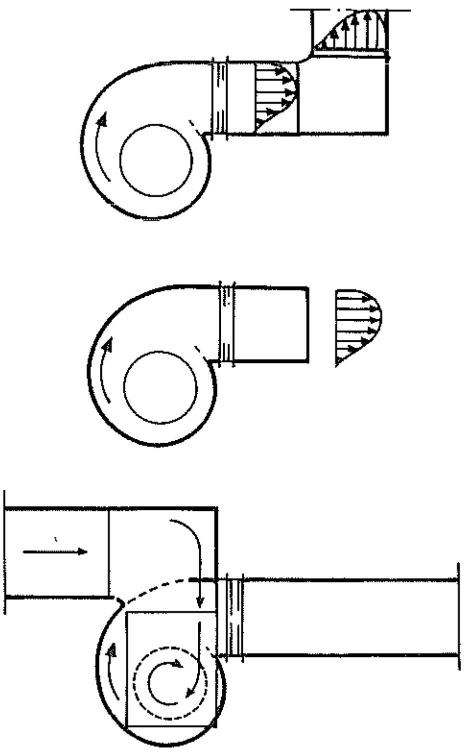


8.5 EFFECTS OF ERRORS IN THE ESTIMATION OF SYSTEM RESISTANCE

Figure 3, curve 'B' shows a situation where an actual duct system has more resistance to flow than was estimated, thus intersecting with the fan characteristic curve, point 'B', at a lower flow rate than design.

There are three common causes of deficient performance of the AHU/system combination:

FIG. 4 EXAMPLES OF SYSTEM EFFECT PROBLEMS



a. High pressure across components immediately downstream of the fan

b. Duct downstream of the unit outlet too short

c. Swirling of air at the fan inlet

a. High pressure across components immediately downstream of the fan.
The pressure drop across components located too close to an AHU discharge will be higher than stated for uniform velocity profile. As Figure 4 indicates the velocity profile of air leaving the outlet is non-uniform for a considerable distance downstream of the outlet.

b. Duct downstream of the unit outlet too short.
In cases where an AHU is discharging directly into free air and not into a duct system, or is fitted only with a short duct length, not all of the available static pressure can be recovered and this results in an effective loss.

c. Swirling of air at the fan inlet.
Unfavourable design of the ducting connecting to the inlet of an AHU fan may cause the air to swirl at the fan inlet. If the air swirls in the same direction as the rotation of the impeller the delivery pressure, and consequently the flow rate, of the fan will be reduced.

8.6. THE SYSTEM EFFECT

The difference between performance characteristics obtained from a unit on a test rig and those occurring in an installation on site is known as the system effect. The system effect for any given configuration is dependent on velocity and will therefore vary across the range of a fan's duty.

The system effect as a function of air velocity or dynamic pressure at the nominal inlet or outlet area of the unit can be calculated in Pascals for various system effect factors, which is added to the system resistance. The pressure drop in the installation is first calculated in the usual manner up to the terminal flanges of the unit. Any system effect on inlet and outlet sides of the unit is added to this value. The total system resistance, including the system effect, is then used for determining the required pressure rise in the unit.

If more than one connection condition is applicable simultaneously, separate system effects should be calculated for each condition and the sum of these system effects should be added to the system resistance.

For details of factors and calculations for specific system effects the reader should refer to the AMCA Fan Application Manual Part 1. This is the most current data available on these effects, however, the HEVAC Association are now conducting a large research project to determine more accurately the effects of ductwork fittings connected directly to the fan inlet or outlet.

9. INSTALLATION AND COMMISSIONING INSTRUCTIONS

9.1 GENERAL

AHUs may be shipped to site as completely assembled packages, or particularly for larger units, they may be sectionalised for shipment and assembled on site.

The complete installation must be such as to provide adequate access to all parts of the unit. The plantroom should be wide enough for the removal of coils. If not, then the coil section should be placed opposite a door or knockout panels. Similar provision may be necessary for components such as fan shafts. If space is limited then all piping, filter access, motor and drive access, electrical connections etc., should be on the same side of the unit with a minimum of l.5 metres clearance. It may also be necessary to leave a minimum of 0.5 metres on the other side, for maintenance and painting of the unit casing.

All units should be installed in a level manner in accordance with the manufacturer's requirements.

To prevent casing corrosion the unit should not be placed directly onto concrete without a vapour barrier between the two.

As each section is joined in place it should be checked visually for possible bypass or leakage and all openings or gaps sealed.

9.2. INTAKE AND EXHAUST LOUVRES

Intake and exhaust louvres should not be directed towards residential or other quiet areas unless provision is made for baffling or attenuating unit noise. Otherwise the requirements of the Environmental Pollution Act may not be met.

It may be necessary to incorporate a properly drained space between intake louvres and outdoor air dampers to collect snow or rain which may pass through louvres.

It is recommended that great care be taken to site air intakes away from contaminated air sources.

9.3. FILTER SECTION

Adequate space should be available at the access side of the filter section for the removal and replacement of the filter elements.

9.4. COILS – SYSTEM PIPING

All steam, water and refrigerant piping must be in conformance with good system practice for proper operation of the coils.

The coil connections or unit casing must not take the weight of pipework and valves. These must be supported separately, unless agreed otherwise beforehand with the AHU manufacturer. All piping branches should be offset with union or flanged joints to permit removal of coils without disturbing mains, drop branches or control valves. All pipe openings in the unit casings should be caulked and have airtight escutcheon plates or grommets fitted by the manufacturer to reduce air leakage.

All water coils should be vented of air prior to and after initial start-up.

If water cooling coils are positioned upstream of the heating coil then almost certainly it will be necessary to drain the cooling coil or supply a safety control to prevent the water freezing.

All water flow connections should be connected to the header nearest the air leaving face to ensure counterflow, otherwise output will be greatly reduced. Steam connections must be at the top of the header and condensate at the bottom. With hot or chilled water coils it does not matter if the flow is at the top or bottom of the header.

Do not bush down coil condense connections, but make them full size up to the scale pocket.

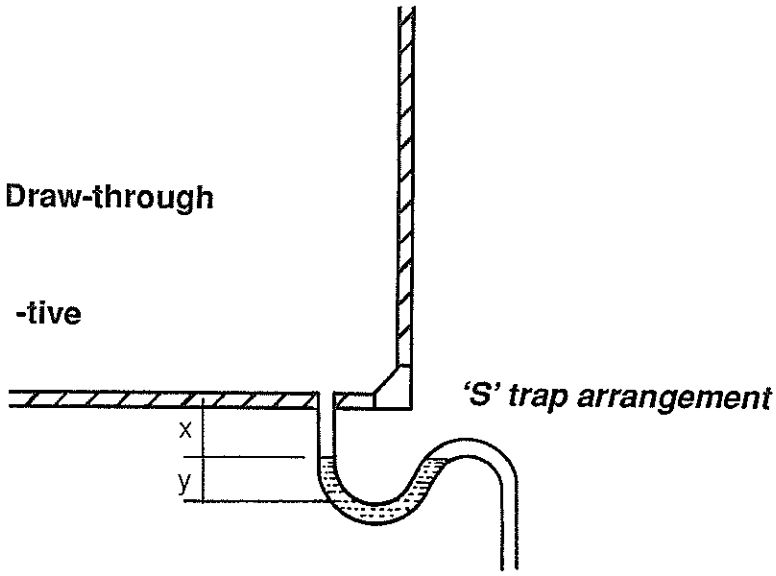
9.5. DRAIN CONNECTIONS

All drains must be correctly trapped, see Figure 5. Incorrect trapping can result in flooding within the unit and consequent flooding of the plantroom.

Drain lines should be a minimum of the same size as the drain pan connection. This must pitch downwards continuously l0mm/metre to a tundish or other form of air break. There must always be an air break.

All drain lines should be insulated where passing through any space where damage from condensation drip might occur. Drainage fittings with clean-out plugs should be used at each change of direction in the drain line.

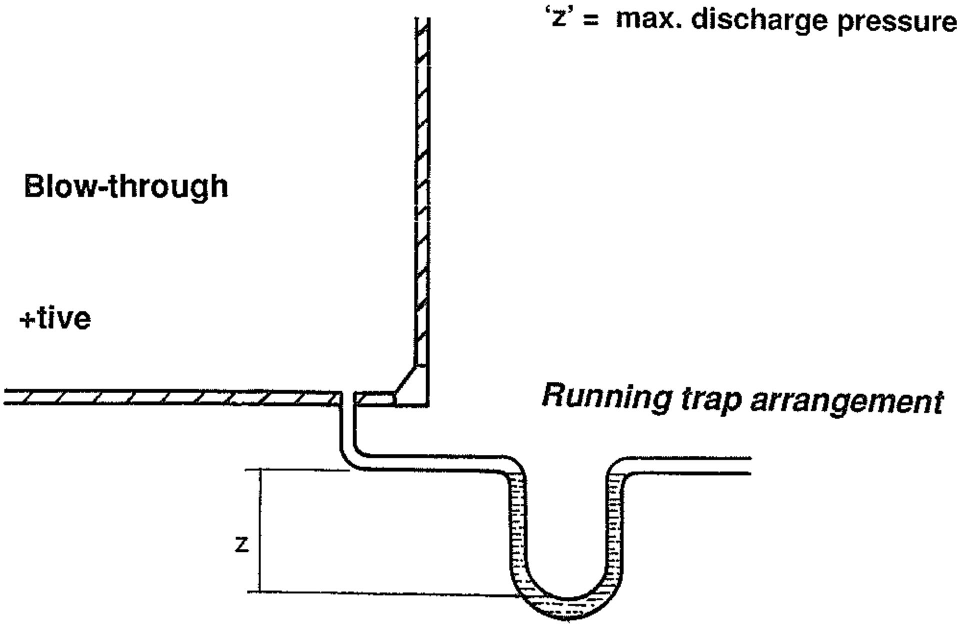
FIG. 5 RECOMMENDED CONDENSATE TRAPPING METHODS



'x' = max. suction pressure + 50mm

'y' = ½ max. suction pressure

'z' = max. discharge pressure + 50mm



9.6. FAN SECTION

The fan and motor assembly is normally fitted on anti-vibration mountings. Check that all transit fixings are removed/released.

- Check that all anti-vibration mountings are moving freely.
- Check drive belt tension and alignment.

9.7. WIRING

All wiring must be installed in accordance with the latest IEE Regulations and the requirements of the Health and Safety Executive.

Where cabling penetrates the unit casing, gland plates or other means of sealing must be used.

All final connections to moving equipment or to vibration and sound insulated sections should be run in flexible conduit or cable with adequate slack for maintenance purposes.

If wiring between internal components and outside terminal boxes is required then manufacturers should be informed of any special requirements.

9.8. DUCT CONNECTIONS

Where the unit or fan section is mounted on external anti-vibration mountings, flexible connections must be provided to prevent vibration transmission.

The weight of ducting or air plenums should not be transferred onto the AHU, unless agreed otherwise beforehand with the manufacturer.

9.9. UNIT COMMISSIONING

Prior to start up make a visual investigation to check that all protective coverings are removed, the components are correctly installed and the motors have the correct direction of rotation. All site debris and rubbish should be removed.

- Zero manometers
- Prime drain traps
- Check fan motor line currents are within nameplate ratings.
- Check fan speed against manufacturer's data.
- Check correct operation of air dampers.
- Check fan air volume across its complete range of operation.
- Re-tension belts after approximately 48 hours running.

10. MAINTENANCE REQUIREMENTS

AHUs, as with any mechanical equipment, require periodic maintenance. The following is a recommended checklist to be used as a guide to planned maintenance.

10.1. MIXING BOX – ANNUAL INSPECTION

- Check duct connections to mixing box are correctly made and there is no excessive air ingress or leakage.
- Check operation and setting of damper blades and operating mechanisms to ensure free movement. Lubricate where necessary in accordance with the manufacturer's recommendations.

10.2. FILTER SECTION – PERIODIC INSPECTION

- To ensure unit operates at maximum efficiency, filters must be maintained on a regular basis.

The length of time between the replacement of throw away filters or the cleaning of permanent type filters will be dependent upon the condition of the air. A six week cycle is normal, but more frequent servicing may be required in certain environments.

10.3. FACE AND BYPASS DAMPERS – ANNUAL INSPECTION

- Check operation and setting of damper blades and operating mechanism to ensure free movement. Lubricate where necessary in accordance with the manufacturer's recommendations.

10.4. COILS – ANNUAL INSPECTION

- Check coil connections on steam and water coils for leaks. Rectify as necessary.
- Carry out a refrigerant leak check on Direct Expansion coils.
- Inspect coil fin surfaces for dirt, lint and other foreign matter. Any foreign material should be removed by careful brushing with a soft brush, by vacuuming or in excessive cases by washing down the coil, to ensure maximum operating efficiency.

If there is a particularly heavy accumulation of foreign material then more frequent replacement or cleaning of filters may be indicated or there may be air bypassing the filters.

- Check the drain pan and drain line on cooling coils and ensure that condensate is being properly drained and that there are no restrictions in the drain lines. Clean with a suitable biocide to prevent bacterial growth.
- Check operation of steam traps and clean out strainers.

10.5. FAN SECTION – PERIODIC INSPECTION

- Check fan shaft bearings for satisfactory operation every six months. Lubricate where required in accordance with manufacturer's recommended instructions.

Some installations may require more frequent attention if subjected to severe service or industrial atmospheric conditions.

- Check fan impellers are correctly mounted on fan shafts.
- Check motor operation for noise and vibration. Lubricate motor bearings in accordance with manufacturer's recommended instructions.
- Check pulleys on fan shaft and motor every six months for correct alignment and positive fixing to the shafts. Re-torque fixing arrangement where necessary.

- Check belts for wear and correct alignment and tension every six months. Proper belt tension and the necessary adjustment will depend upon the type of belts used.
- Check belt guards and ensure correct re-fitting after any adjustments have been made.

10.6. GENERAL MAINTENANCE – ANNUAL INSPECTION

- Check casing for excessive ingress or leakage of air through gasketed joints between sections and around inspection doors or covers.
- Check mounting of unit and the satisfactory operation of anti-vibration mounts.
- Check for signs of corrosion and treat as necessary.
- Check that all fresh air dampers shut properly
- Check that all controls are operating satisfactorily

APPENDIX A – TYPICAL STEAM PIPEWORK ARRANGEMENTS

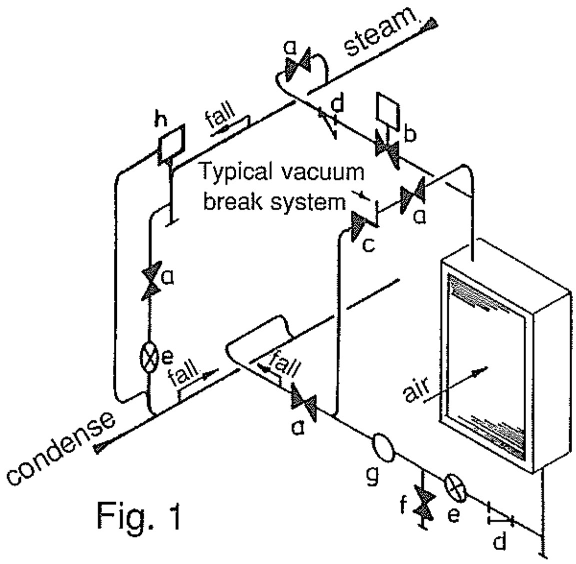


Fig. 1

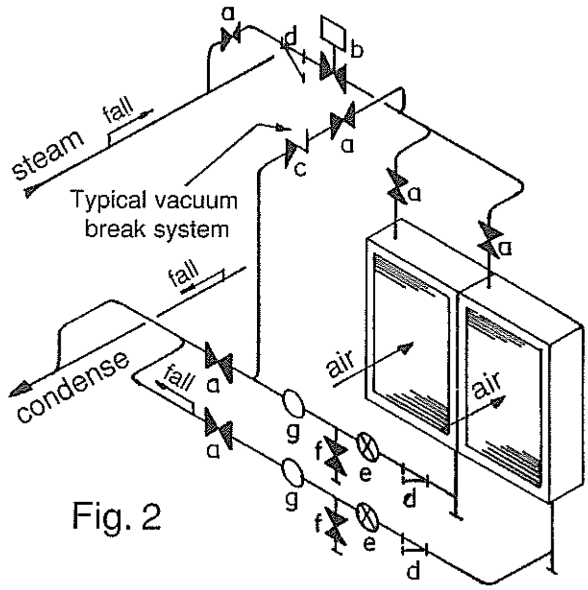


Fig. 2

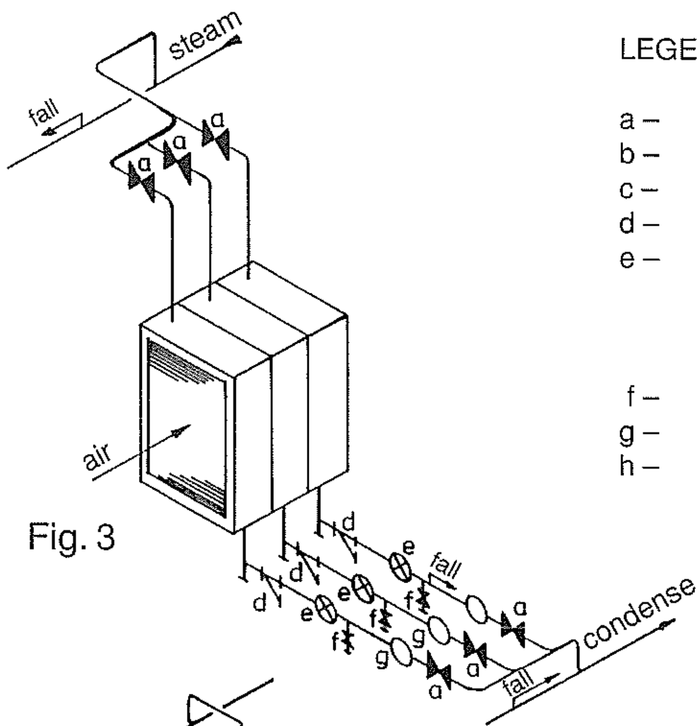


Fig. 3

LEGEND

a – Isolating valve
b – Control valve
c – Check valve
d – Strainer
e – Float type trap with thermostatic air release mechanism
Bucket type trap is suitable alternative on high pressure systems
f – Drain cock
g – Sight glass
h – Air Vent

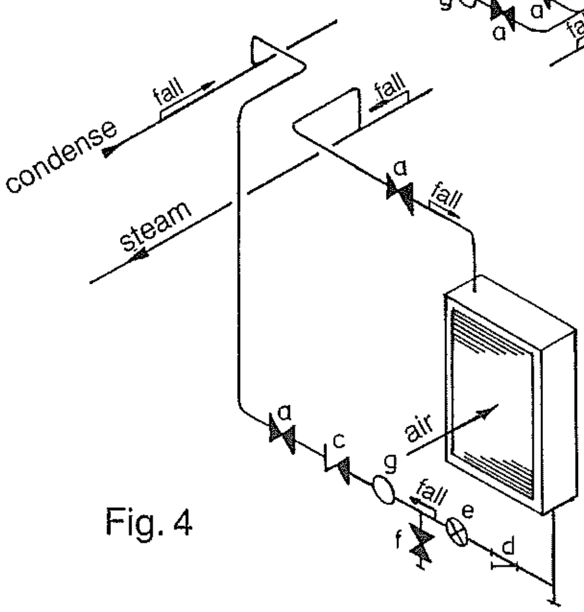


Fig. 4

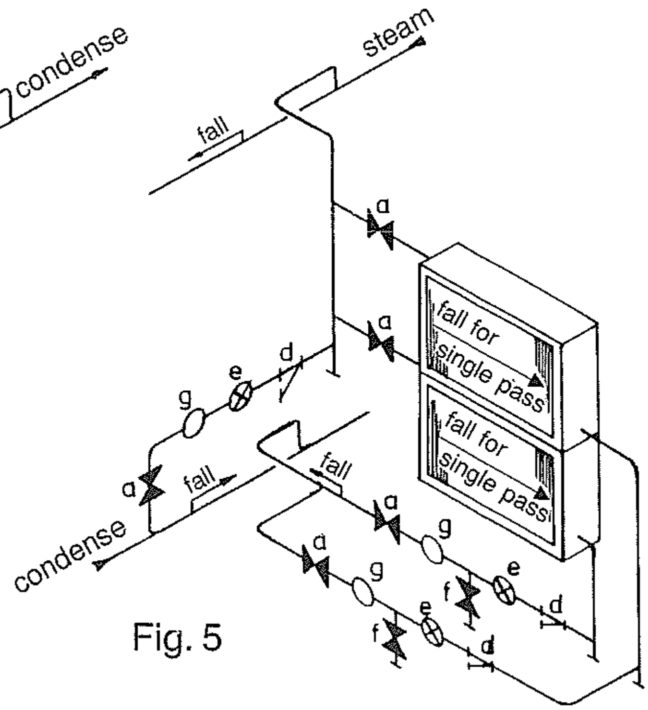


Fig. 5

DIAGRAMS:

Figure 1: **VERTICAL TUBE HEATHER WITH CONTROL VALVE FITTED**
Also showing venting and trapping of steam mains

Figure 2: **VERTICAL TUBE HEATER SECTIONS ASSEMBLED SIDE BY SIDE**
Individual trapping is recommended for best results

Figure 3: **VERTICAL TUBE HEATERS – SERIES CONNECTED**
Individual trapping of each section is essential Traps and control valves (if fitted) must be sized for the duty of each bank.
Note: If control valves are fitted, each bank must be individually controlled and vacuum break devices included.

APPROXIMATE PERCENTAGE OF OUTPUT PER BANK

Number of banks	Bank number in direction of airflow			
	1	2	3	4
1	100	-	-	-
2	55	45	-	-
3	41	33	26	-
4	34	27	22	17

Figure 4: **VERTICAL TUBE HEATER WITH CONDENSATE LIFT TO HIGH LEVEL MAIN**
Note: Output should be controlled by face and bypass dampers. Do not fit control valves unless a condensate pump set is fitted in lieu of the float traps.

Figure 5: **HORIZONTAL TUBE HEATER SECTIONS ONE ABOVE THE OTHER**
Each section must be individually trapped.