Blowing hot and cold

The element of space heating & air treatment covers a wide and varied list of installations. This month *Silk and Frazier* looks at air conditioning and ventilation.

ELEMENT DESCRIPTION

Element 5F:
Heating only, by water and/or steam, ducted warm air, electricity and local heating.
Heating with ventilation (air treated locally or centrally).
Heating with cooling (air treated locally or centrally).

AIR CONDITIONING provides and maintains a desirable internal atmospheric environment irrespective of external conditions. It can be specifically defined as the delivery of air that can be warmed or cooled and have its moisture content (humidity) raised or lowered. Ventilation is the delivery of air that can be warmed.

The generally accepted preferences for the internal temperature of commercial buildings are:

- Winter conditions : 18° - 22°C
- Summer conditions: 21° - 24°C
- Relative humidity : 40%-60%

In winter the air supply (external or recirculated) is cleaned and warmed, which lowers the relative humidity. Therefore humidifying plant (spray or steam injection) is introduced to correct the levels.

In summer the air supply (external or recirculated) is cleaned and cooled which raises the relative humidity.

Cooling loads
The choice and design of air treatment systems is interdependent on the building construction. Careful thought must be given to each element of a building to ensure low running costs and generally to result in an energy friendly building (see example right).

Space requirements
Consideration must be given to the loss of lettable space occupied by plant and equipment. In a typical office block of 10 000m² gross floor area, relative figures may be:

- Perimeter induction units - 376m²
- All -air single duct VAV with ceiling distribution - 236m²
- Four pipe fan coil system - 190m²
- Variable refrigerant volume system - 130m²

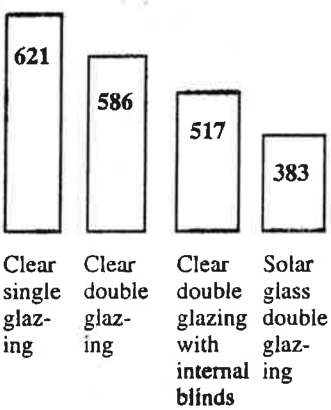
Given that the typical office block has, say 8 000m² nett lettable area, then the effective loss of each system is:

- Perimeter induction units - 4.70%
- All-air single duct VAV with ceiling distribution - 2.95%
- Four pipe fan coil system - 2.38%
- Variable refrigerant volume system - 1.63%

When is air conditioning necessary?
Some of the conditions that would generate the need for air conditioning are listed as follows:

- The building has high heat gains. This could be brought about by solar effect, electronic equipment, computers, lighting, or occupancy density.
- The building is effectively sealed, ie double glazed etc.
- Deep plan buildings where the central core is too distant from the windows to benefit from natural ventilation.
- Buildings that naturally have a high density occupancy, ie theatres, cinemas, restaurants, conference rooms etc.
- Where close control of temperature or humidity is required, ie computer suites, museums, paper stores etc.
- Areas of confined space and precision working, ie operating theatres and laboratories.
- Buildings in noisy environments where the windows cannot be left open.
- Areas where the exclusion of airborne dust is essential, ie micro-chip assembly and animal houses.

Comparative cooling loads using different types of glazing



Basic elements
The basic elements in a system are:

- Fans to move air.
- Filters to clean air.
- Cooling plant.
- Heating plant (hot water, steam, electrical).
- Humidification / dehumidification plant.
- Control systems.

SYSTEMS

To consider the various systems available we look first at a typical air conditioning system capable of serving a large single room (see **Figure 1** overleaf).

It can be seen from the diagram that air is drawn in from outside, filtered and preheated and then mixed with recirculated air.

After further filtering it is then either cooled using chilled water from the condenser/evaporator plant or heated using hot water from a boiler system.

Humidification is then adjusted and the treated air blown into the room. The operations of heating/cooling/humidification/recirculation etc, are controlled by motorised valves run from sensors.

In an alternative system the cooling coil can be connected directly to the refrigerating plant and contains the actual refrigerent gas.

On expansion, as the gas leaves the condenser, cooling takes place and is known as a direct expansion (DX) system.

Fan coil systems
Local reheating and cooling to each room (zone) can be introduced by using fan coil units. The air can be conditioned first in a central plant room and distributed to each zone for reheating/cooling as required. This is referred to as an induction system, as the primary air from the central plant is mixed with air from the room (secondary air) by induction in the local unit.

Fan coils may be fed with a two pipe (heating) or four pipe (heating and cooling) system. A three pipe system can be used (mixed return pipe) but this is not very common. As the central plant deals primarily with the volume of air for ventilation purposes, duct sizes can be reduced.

A cheaper version of a fan coil system is obtained where the units are positioned on an external wall and take in external air directly, thereby eliminating the need for central plant. This gives no humidity control and the system is subject to high / low velocities dependent upon the wind direction and strength.

Self contained unit
Totally self contained air conditioning units (see **Figure 2** overleaf) can be introduced on external walls but due to lack of centralisation tend to be expensive.

Variable refrigerent volume (VRV)
The relatively new VRV system is becoming more popular with clients as running costs are reported to be fairly low. However equivalent installation costs are somewhere between the fan coil system and a full VAV air system (see next page).
The VRV system utilises a nitrogen refrigerent as a heat transfer medium similar to a 'split system' with internal fan coil evaporators and external compressor/condenser unit.

Generally used for cooling only, the system can be extended by the introduction of a heat pump at the internal unit to produce a heating and cooling system.

For complete control of flow etc, the introduction of an inverter unit is necessary.

Variable air volume (VAV)
Basic all-air systems cater for differing loads by adjusting the temperature at a constant volume.

However the VAV system adjusts the volume of air at a constant temperature. This adjusted volume is registered on pressure controllers which operate devices to reduce the volume output of the central plant accordingly, thereby giving running cost economies.

When the volume of supply air is varied, a corresponding adjustment must be made in the extract system, otherwise an over pressurised building would result.

The VAV system is popular because of its adaptability to suit revised partition layouts in office buildings.

Constant air volume
A simplification of this system, known as Constant Air Volume (CAV) is possible where control of individual rooms is not required and areas or zones will run at the same temperature throughout. Control of air temperature and humidity is done at the control plant with the entire zone supplied receiving the same treated air. This can give rise to problems where some rooms have higher heat gains than others and careful consideration is necessary to determine optimum zoning.
The relative effect of a number of different parameters on different systems can be seen in the table below right.

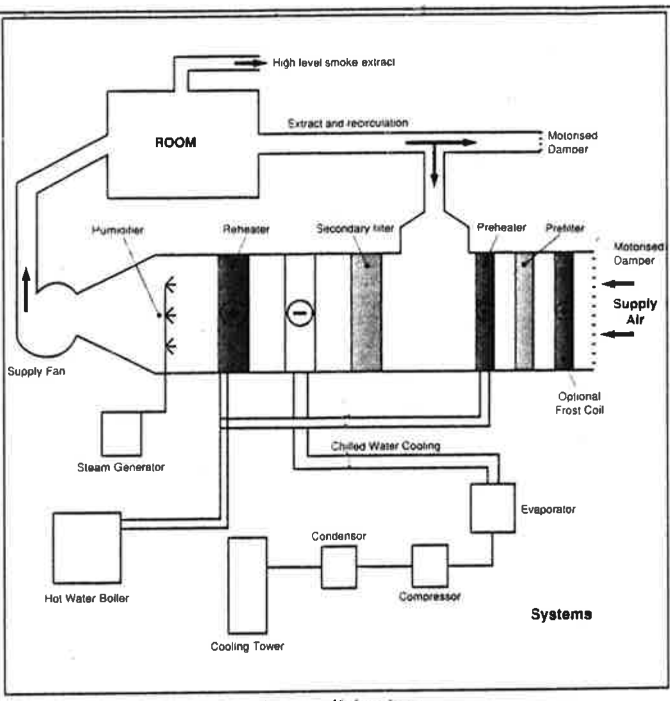


Figure 1: single room air conditioning system

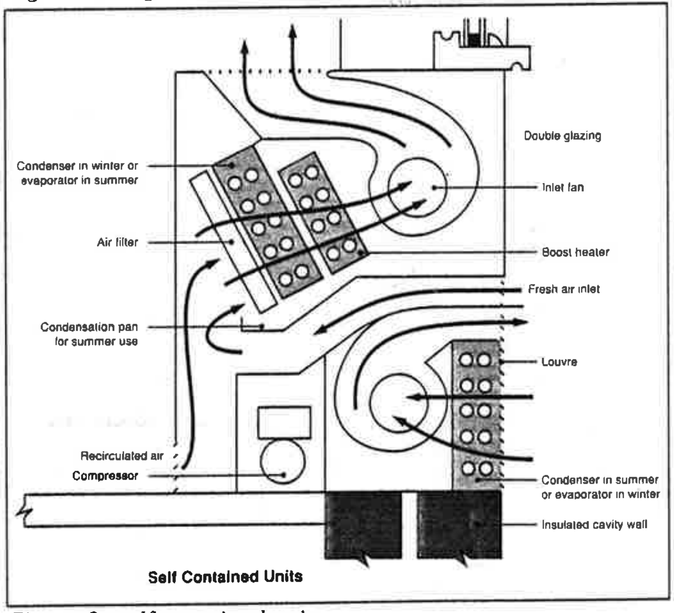


Figure 2: self contained units

Spatial impact	2 Pipe FCU	4 Pipe FCU	CAV	VAV
Plant space	average	average	poor	poor
Riser shafts	average	average	poor	poor
Floor space encroachment	poor	poor	good	good
Ceiling depth	average	average	poor	poor
Quality of performance				
Temperature control	poor	good	average	excellent
Humidity control	poor	poor	average	good
Air distribution	average	average	good	excellent
Noise	average	average	good	good
Costs				
Capital	low	medium	medium	high
Operating	low	medium	medium	med/high
Flexibility				
Partition arrangement	good	good	average	excellent
Increased cooling load	good	good	average	good
Increased ventilation	average	average	good	excellent

Above: effect of different parameters on individual systems

VENTILATION

Ventilation is required in a building for a number of reasons:

- To remove body odours
- To remove carbon dioxide
- To remove water vapours
- To remove dust
- To remove fumes and smoke
- To remove excessive heat

Air is replaced with fresh air, creating movement inside the space. Under normal circumstances an air velocity of between 0.15m and 0.5m per second is acceptable.
Natural ventilation can be achieved in a number of ways:

- **Wind pressure** - wind causes a positive pressure to act on the windward side of a building and a negative pressure to act on the leeward side. By positioning inlets and outlets correctly, cross ventilation will take place.
- **Stack effect** - this is created by the difference in temperature between the air inside and the air outside a building.

The warmer, less dense air inside is displaced by the cooler denser air from outside.
The greater the vertical distance between the inlet and outlet openings, the greater will be the stack effect.

- **Wind pressure and stack effect** - when a wind is present and the air inside a building is warmer than the air outside, ventilation will take place by both wind pressure and the stack effect. With natural ventilation however, it is not possible to ensure specified air changes or to filter the air entering a building.

Mechanical ventilation
This employs an electrically driven fan to provide the necessary air movement to provide positive ventilation at all times and can incorporate the use of filters. Three types of system can be used:

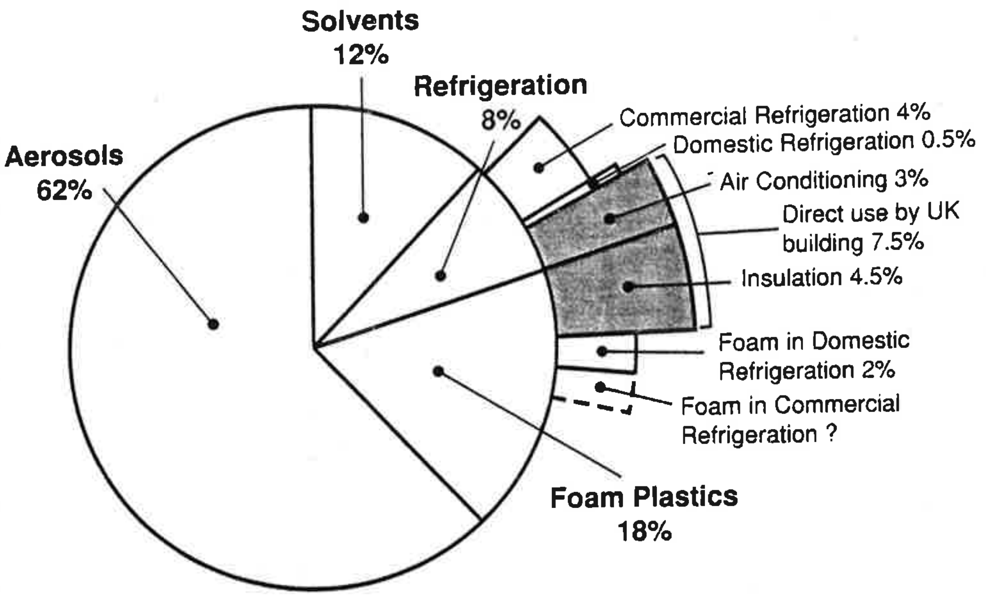
- **Natural inlet and mechanical extract** - this is probably the most commonly used system and creates a negative pressure on the fan inlet, drawing the room air toward it, which is then replaced by fresh air from outside. Fans should be sized to accommodate the design air change and allow for fan static pressure to counteract wind pressure. For example, a bathroom with a WC requires a minimum extract rate of $40m^3$ /h.
- **Mechanical inlet and natural extract** - with this system the air must be heated before being forced into the building. This can be achieved using central plant and then ducted around the building.
- **Mechanical inlet and extract** - this gives the best possible system for ventilation but is also the most expensive.

Recirculation can be incorporated to reduce running costs. Air can be extracted through the light fittings, improving the lighting efficiency and further reducing running costs. The extract fan is sized to be slightly smaller than the inlet fan, thereby creating pressurisation inside the building and preventing the entry of dust and draughts.
There are three types of fans used:

- **Propeller fans** - blades fixed

at an angle to the hub which creates low pressure only.

- **Centrifugal fans** - impeller with curved blades revolving inside a casing. This can develop high pressure and the inlet and outlet are at 90° to each other.
- **Axial flow fans** - impeller with aerofoil section blades rotating inside a cylindrical casing - similar uses to the centrifugal fan but can be used in line.



Estimated UK use of CFCs in 1986

CFC'S

It is now generally accepted that CFC's help to deplete the ozone layer and also contribute to the Greenhouse effect and it is therefore essential to reduce their usage. Alternatives such as HCFCs (hydrochlorofluorocarbons) and HFCs (hydrofluorocarbons) can be substituted and have a lesser effect on the environment.

It is recommended that CFCs R11 and R12 are not used in new plant and that R22 should be considered as a replacement until safer alternatives become available. Plant utilising R11 and R12 has a high potential for early redundancy if direct replacement is restricted in the future. With some alteration to plant however, drop-in replacements such as R134a and R123 can be used.

Unfortunately, the use of alternatives in the chiller plant for air conditioning require a higher power consumption to achieve the same effect.

SICK BUILDING SYNDROME

Building sickness is a syndrome of complaints that covers non-specific feelings of malaise.

Generally identified with the concept of air conditioning in buildings, little has been proved about its specific causes. Areas identified as potential causes however are:

- Sealed airtight buildings
- Air conditioning installations
- Use of materials giving off irritating fumes or dust
- Flicker or glare from fluorescent lighting
- Energy conservation measures
- Lack of individual control over environmental conditions

The medical conditions associated with SBS are :

- Dryness of skin, eyes, throat and nose
- Allergic symptoms such as watery eyes or runny nose
- Asthmatic conditions such as a tight chest
- A general feeling of lethargy, headache or malaise

While current evidence suggests that there is no single cause of SBS, detailed design of mechanical installations should take the following into account:

- Design of plant rooms and services should allow for adequate maintenence of all equipment, concealed devices and duct spaces.
- A good clean air supply is important and consideration should be given to the need for air conditioning in a particular building.
- Avoidance of materials that emit toxic chemicals.
- The use of dedicated ventilation systems to designated areas for occupants to smoke, thereby avoiding any recirculation of smoking odours.

Below: properties of CFC's and their alternatives.

		Ozone depletion potential (R11 =1)	Greenhouse potential (CO_2=1)
R11	CFC	1	3300
R12	CFC	1	10000
R22	HCFC	0.05	1100
R123	HCFC	0.02	50
R125	HFC	0	1900
R134a	HFC	0	900

ESTIMATING AND ECONOMICS

When the client asks for air conditioning in his building, he may not always mean precisely that. Very often his perception of what he calls air conditioning is in fact comfort cooling - a much simpler and cheaper option.

The QS should be able to identify and advise the client as to what basic type of system he actually needs, together with square metre costs for each general type of installation.

Costing in more detail and identifying the subtle differences of individual requirements within one system should however, be the role of the QS specialising in that field.

Costs

Installation costs will vary from project to project, depending upon the individual refinements called for. However, general comparative price ranges for a typical medium sized office building would be as follows:

- Two pipe fan coil system with supply air and ventilation system- **£100-£130/m²**
- Four pipe fan coil system with supply air and ventilation system **- £110 - £150 / m²**
- Constant air volume system **- £130 - £155 /m²**
- Variable refrigerent volume system with inverter and supply air and ventilation system **- £140 - £165 /m²**
- Variable air volume system **- £145 - £180 /m²**

Running costs

Similarly, running costs per annum for a medium sized office block of 10 000 m² gross floor area may be:

- Two pipe fan coil system with supply air and ventilation system - **£7 000 pa**
- Four pipe fan coil system with supply air and ventilation system **- £9 000 pa**
- Constant air volume system **- £8 500 pa**
- Variable refrigerent volume system with inverter and supply air and ventilation system **- £6 500 pa**
- Variable air volume system **- £10 000 pa**

Combined installations
Various combinations of different installations are in common usage, aimed at satisfying the individual requirements of the client.

The use of a two pipe fan coil system with ceiling distribution to provide cooling, together with a perimeter low pressure hot water heating system, is often preferred to a standard four pipe fan coil system.

The perimeter heating can help to offset downdraughts from large window areas and also has the psychological advantage for occupants of providing a heating source they can touch.

The cost of a low pressure hot water perimeter heating system would be between £25 - £35 /m^2 which, when added to the cost of a two pipe fan coil system of, for example, £120 /m^2, is less economic than a four pipe fan coil system.

Life cycle costing
Considerations for life cycle costing should be given to:

- Capital cost.
- Energy usage
- Maintenance
- Servicing
- Replacing spare parts
- Indirect costs, ie finishing, reinstatement following routine work etc.

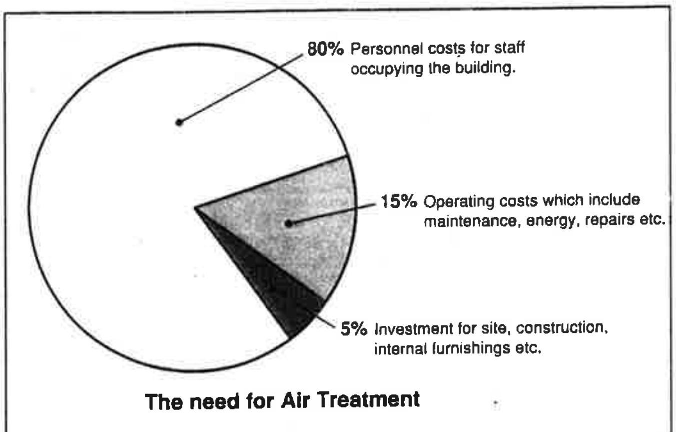


Figure 4.

- System replacement cost, ie life of installation may be 20 years within a building of 60 years' predicted life.

Air treatment
Distribution of total costs for an office building evaluated over a period of 30 years shows a large percentage invested in personnel (see graph above).

The predicted percentage dissatisfied (PPD) of a group of people as a function of temperature deviation from optimum can be shown as in **Figure 5.** Adjusting the temperature by 1°C results in a very small number of dissatisfied people, whereas, given an average internal/external temperature difference of 10°C, a reduction of 1°C represents 10% of the running costs.

BMS

The term BMS can be interpreted in two different ways:

- **Building Monitor System**

With this system room sensors, duct detectors and the like, communicate information back to a central console, giving readouts of the achieved air temperatures and flow rates.

With this information the building engineer can manually adjust valves and pump rates within the central plant room or locally at floor levels to modify the working environment.

Costs vary widely, depending upon the level of sophistication, but generally costs are in the order of £5 /m^2.

- **Building Management System**

This system comprises a higher level of technology and again, via sensor, can report to a central console giving current readouts. However the computer control can then react to these readouts and, using motorised valves etc, adjust the flow rates and temperature settings automatically to meet the required parameters set by the user.

As with most computer software, the range of sophistication is very wide and so therefore is the cost. A typical middle range system would cost between £10-£15 /m^2.

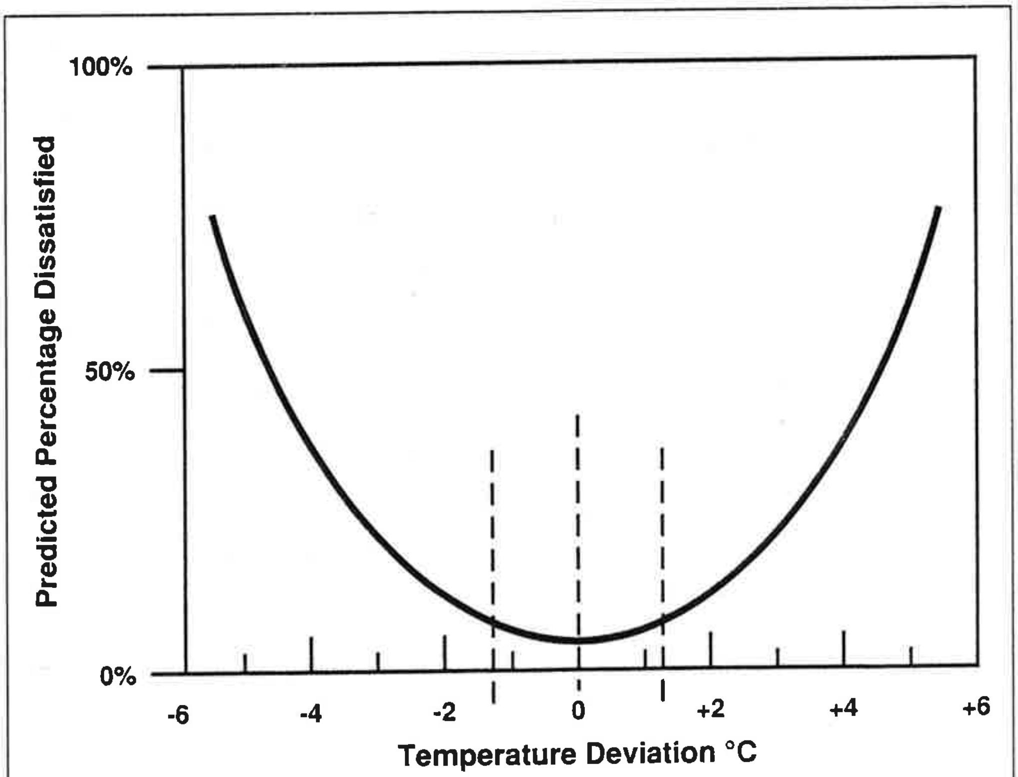


Figure 5.

REFERENCES

Heating and air conditioning of buildings - Faber and Keller.
Building services and equipment - F Hall.
Air conditioning system design for buildings - AFC Sherratt.

THE INFORMATION FOR THIS ARTICLE WAS RESEARCHED AND COMPILED FOR *CQS* BY MICHAEL A HOOK OF PRISM AT SILK AND FRAZIER.

CORRECTION
CQS would like to point out to readers of last month's article on roofing, that the **Bitumen Roof Coatings Manufacturers Association** changed its name to the European Liquid Roofing Association (ELRA) two and a half years ago. Both this association and **The Flat Roofing Contractors Advisory Board** have moved to new offices at: Fields House, Gower Road, Haywards Heath, West Sussex, RH16 4PL. They can be reached by telephone on 0444 417458 and 0444 440027 respectively.