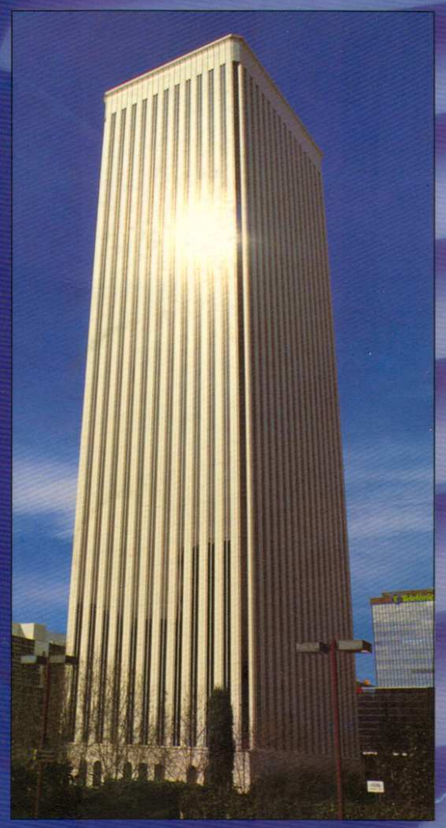
G Nr. 519
Vieta BI 11

# AIR CONDITIONING FOR COMMERCIAL BUILDINGS



## NEW AND REFURBISHMENT

Carrier

**LONDON South & East**
Airport Estate, Biggin Hill, Kent TN16 3BW.
Tel: 0959 571211. Telex: 957157. Fax: 0959 571009.

**LONDON North & West**
Priory House, Marsh Road, Alperton Lane,
Wembley, Middlesex HAO 1ES.
Tel: 081 991 2000. Telex: 27346. Fax: 081 998 0993.

**THE NORTH**
Unit 3, Parkway Four, Longbridge Road,
Trafford Park, Manchester M17 1SN.
Tel: 061 872 7035. Telex: 666946. Fax: 061 872 0318.

**THE MIDLANDS**
12/14 Woodgate Business Park, Kettles Wood Drive,
Woodgate, Birmingham B32 3DB.
Tel: 021 421 7661. Telex: 339140. Fax: 021 421 8147.

**WALES & THE WEST**
7 Crown Glass Place, Nailsea, Bristol,
Avon BS19 2EW
Tel: 0275 854011. Fax: 0275 855241.

**ADMINISTRATIVE HEAD OFFICE**
Carrier House, The Crescent, Leatherhead,
Surrey KT22 8DY.
Tel: 0372 376000. Telex: 8955231. Fax: 0372 386286.

**Sabiedrība LAFIVENTS**
Ventilācija un gaisa kondicionēšana no tehniskā risinājuma un projekta līdz piegādēm un realizācijai
LAFIVENTS Licence Nr. 514

Mūkusalas iela 73A, Rīga, LV 1004 Tālr. 7627787; 7617671 Tālr./fakss 7629800
Mob.tālr. 9356386; 9220047

Carrier

**Carrier Air Conditioning**
A Division of Carrier Holdings Limited

Produced by Peter Sawell & Partners Limited, London. July 1992 - 016

## CONTENTS


Introduction 1

Building owner objectives 2

Factors affecting choice 4

Moduline systems 6

ATM zonal systems 12

Hydronic systems 14

Heat pump systems 16

VVT systems 17

Induction systems 18

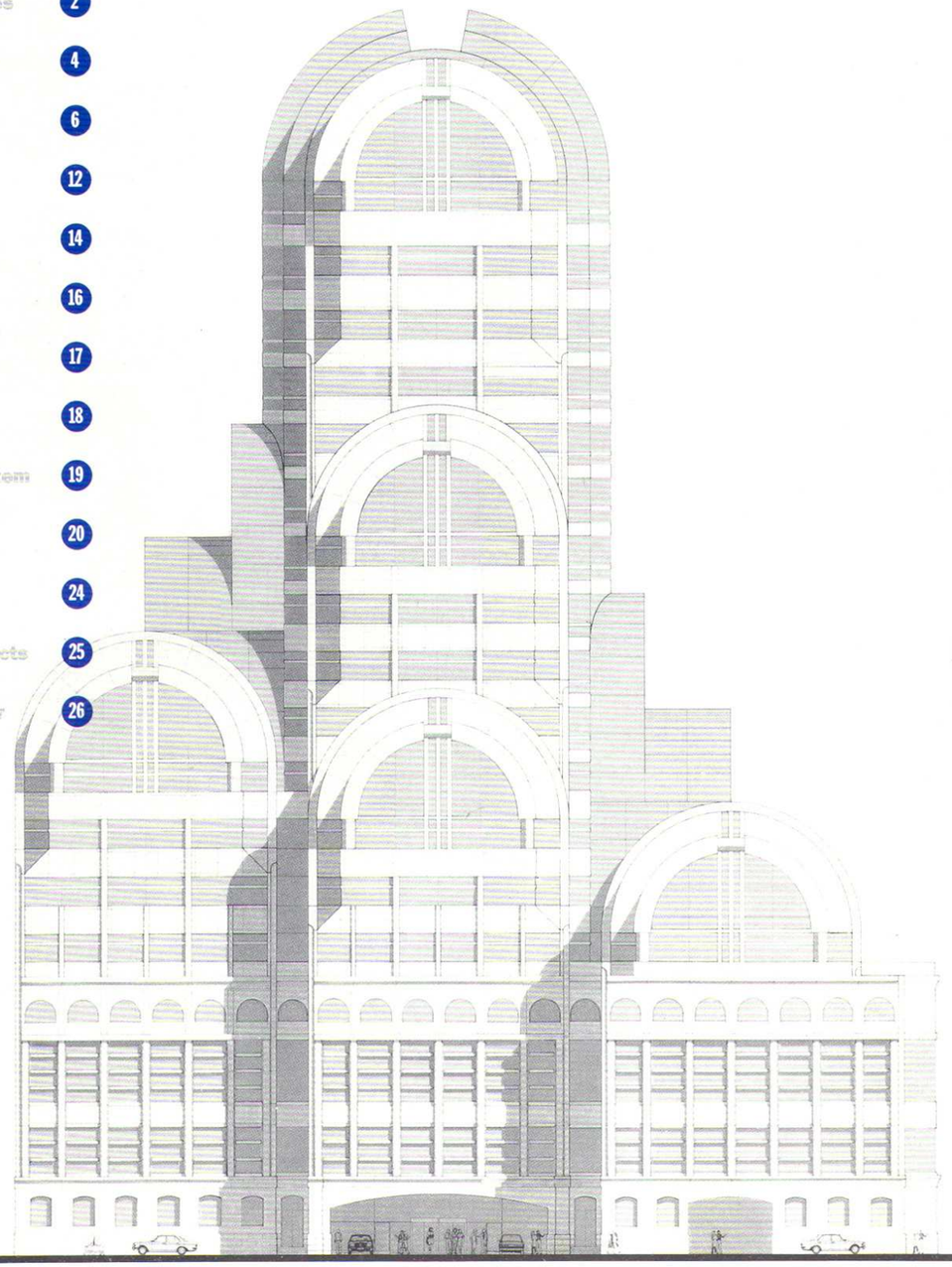
Ice thermal storage system 19

Some retail options 20

Computer aided design 24

The world's finest products 25

Where to contact Carrier 26

*54 Lombard Street, London. Architect GMW Partnership. Reproduced with kind permission of Fleetway House Construction Management Ltd.*



## INTRODUCTION

Today's working environment is too important to leave to chance. Major advances, both in the expectations of staff and in the application of office technology, have created new demands for the building developer and the project team.

As recently as the 1960s, building services – heating, ventilating and air conditioning – were relatively minor elements in specification and design. They were provided as adjuncts to the building structure.

Now, as we approach the 21st century, they are of prime importance, not only in new development but in the refurbishment of existing property – where upgrading of environmental standards is an essential means of maintaining market values. Increasingly, environmental issues such as the use of CFCs, Sick Building Syndrome, indoor air quality and Legionella must be considered at the design stage.

Building services today represent up to half the total contract value, and require detailed planning from initial concept stage.

We are already in the age of the "intelligent building". From the outset, fabric and services are often designed as complementary facets of a single structure capable of harnessing, to the fullest extent, the potential of its electronic infrastructure.

Finely-tuned microprocessor controls on today's equipment ensure optimum environmental performance for the lowest-possible energy costs. They can be self-diagnostic and completely accessible to remote monitoring for ease of maintenance.

Modern systems are above all, operationally flexible, and so fully capable of sustaining mini-environments on a floor-by-floor or even zone-by-zone basis, even in small and medium-sized buildings. They can, therefore, cope with the widely-differing needs of showrooms and sales areas, storage space, production facilities, directors' offices, conference rooms and guest or visitor accommodation - in the same building.

Designing the appropriate system for today's commercial environment is a specialist role for the qualified building services engineer. With total energy costs, operational flexibility and increasing ecological awareness the constant concerns of building owners, occupiers and managers, expert advice is critical for the achievement of successful installations in office blocks, hotels, shopping malls, distribution centres, "high-tech" units and leisure complexes.

The building services engineer's experience of commercial property is of invaluable assistance to the building owner and the project team as a whole.

It will be a major contribution in ensuring that the development is not only attractive to the market place and comfortable for its occupants, but also energy efficient in operation and environmentally caring.

# Services Design - the building owner objectives

Decisions on the installation - or upgrading - of an air-conditioning system have major implications for both capital and running costs and environmental safety.

It is therefore vital for the building owner and for the building services engineer - working within the project team - to draw up a precise specification for the environmental services requirement.

**Key considerations include:**

- the scale of the proposed development
- the age of the property (if existing)
- the importance of operational flexibility
- the content and location of office technology
- the planned population (of staff, visitors, customers, guests)
- the likely patterns of occupancy
- the planned building usage in hours per day
- the environmental characteristics of comparable developments
- the requirement for quality in the completed development
- compliance with evolving environmental legislation.

From an expert analysis of this information, the building services engineer will devise the optimum air conditioning specification for the projected scheme. This will indicate the best-possible use of available systems and technology to meet the essential criteria of the commercial property owner or developer, as shown in the chart opposite.

**The chart indicates the degree of difficulty in achieving the desired criteria and reflects average system costs. Categories, therefore, such as flexibility, aesthetics, sound levels and control options, where given a less than good rating, can generally be improved on a specific project by the acceptance of higher installed costs.**

● **VERY GOOD**

■ **GOOD**

▲ **AVERAGE**

*criteria for air-conditioning installation*

| OPTION CHART: air conditioning systems for commercial properties. | maximum usable/lettable floorspace | maximum in-space flexibility | lowest operating costs | comfortable working environment | compatibility with aesthetic requirements | room sound levels | durability of equipment | ease of maintenance | localised control options | lowest environmental impact | indoor air quality |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. VAV with perimeter heating | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| 2. VAV dual conduit | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| 3. Moduline VAV with reheat | ● | ● | ■ | ● | ● | ● | ■ | ■ | ● | ● | ● |
| 4. Underfloor VAV | ■ | ● | ■ | ● | ● | ● | ■ | ■ | ● | ● | ● |
| 5. Modubox VAV with reheat | ● | ▲ | ■ | ● | ● | ● | ■ | ■ | ● | ● | ● |
| 6. VAV with reheat - floor by floor | ■ | ● | ■ | ● | ● | ■ | ● | ■ | ● | ● | ● |
| 7. Fan powered mixing box | ● | ▲ | ■ | ● | ● | ■ | ■ | ■ | ▲ | ● | ● |
| 8. Fan powered VVT | ● | ● | ● | ● | ● | ■ | ■ | ■ | ● | ● | ■ |
| 9. ATM VAV fan coil - vertical | ● | ● | ■ | ● | ● | ● | ■ | ● | ● | ● | ● |
| 10. ATM VAV fan coil - horizontal | ● | ■ | ■ | ● | ● | ■ | ■ | ▲ | ● | ● | ● |
| 11. Hydronic cassette | ● | ■ | ■ | ■ | ■ | ■ | ■ | ▲ | ● | ▲ | ▲ |
| 12. Vertical fan coils | ▲ | ■ | ■ | ■ | ▲ | ■ | ■ | ■ | ● | ▲ | ▲ |
| 13. Vertical perimeter heat pump | ▲ | ■ | ■ | ■ | ▲ | ■ | ■ | ■ | ● | ■ | ▲ |
| 14. Horizontal heat pump | ● | ■ | ■ | ■ | ■ | ■ | ■ | ▲ | ● | ● | ▲ |
| 15. Variable volume/temp system | ● | ● | ● | ● | ● | ● | ● | ■ | ● | ● | ▲ |
| 16. VAVVT. | ■ | ■ | ■ | ● | ● | ● | ■ | ■ | ● | ● | ■ |
| 17. Vertical induction | ▲ | ■ | ▲ | ■ | ▲ | ■ | ■ | ● | ■ | ▲ | ■ |
| 18. PTAC | ▲ | ▲ | ▲ | ■ | ■ | ▲ | ■ | ■ | ● | ■ | ▲ |
| 20. Roof mounted package | ● | ▲ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ▲ | ● |
| 21. The multiple split air conditioner | ■ | ▲ | ■ | ■ | ▲ | ■ | ■ | ▲ | ● | ▲ | ■ |
| 22. The district cooling system | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 23. Ducted system | ● | ▲ | ▲ | ● | ■ | ● | ● | ● | ▲ | ■ | ■ |

# Air conditioning for new or refurbishment projects - factors affecting choice

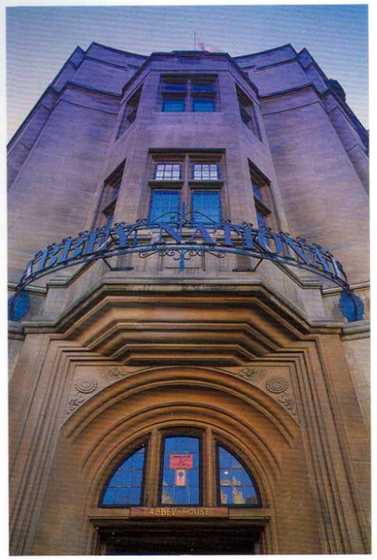
The fundamental issue affecting the selection of an air conditioning system is the nature of the proposed development - new-build or refurbishment. In fact, the relative costs of installing (or upgrading) air conditioning and other services can be a material factor in deciding whether to retain a property, or demolish it and rebuild from scratch.

Ideally new build should offer the client total scope for achieving the perfect system. In reality, although the scope will be much wider, there will still be limitations. Installed to the highest modern standards, it will incorporate the inbuilt flexibility necessary to cope with future changes in demand or use patterns, avoiding any potential problems with large-scale alterations, inherent in the less flexible systems of the past.

The installation will be designed integrally with the fabric of the new development to form a single, responsive, energy-efficient structure. The client should have the choice of the full range of available systems from which to select the best for his purpose.

Refurbishment is naturally more complicated, since neither the client nor the building services engineer has a completely free hand. The first decision to be made is whether to upgrade the existing installation, or to replace it with a modern, purpose designed and usually more energy efficient system.

Normally, it is preferable to strip out the old equipment and start afresh. In the '60s most commercial property was built with no cooling capability at all, and the few buildings that did have air conditioning were served by totally independent heating and cooling systems.



Merely upgrading existing plant, therefore, will generally give a less satisfactory system than that afforded by the installation of more sophisticated systems, with integrated heating and cooling when and where it is needed, and more energy efficient controls.

On the other hand, some commercial buildings put up during the last 30 years may be structurally ill-equipped to carry the weight of a new installation, especially a perimeter system. There is also the question of the loss of valuable usable floorspace.

Again, an older building may be officially listed for its architectural or historic interest, and thus subject to strict conservation constraints. Period features may well have a commercial value of their own, in marketing prestige accommodation; in any case, they must be left unaltered and undamaged by any new services installations.

Assuming that the decision is in favour of a new system, the services engineer and installer need to deploy considerable ingenuity in threading new ductwork pipework through existing or redundant service cores and shafts. False ceilings, which offer a convenient solution in recent and architecturally less significant buildings, are only appropriate in non-sensitive areas of a period property.

Finally, both new developments and refurbishment schemes can be subject to planning restrictions which rule out roof-mounted plant rooms. The choice then lies between an internal location (which will reduce usable floorspace) and the exterior of the site (which may affect access or parking, or even involve the purchase of additional land). Either alternative has financial implications, which need to be expertly assessed.

**The chart relates available air conditioning systems to the physical constraints inherent in the new-build and refurbishment schemes, and reflects the space requirements for a typical installation.**

● **VERY GOOD**

■ **GOOD**

▲ **AVERAGE**

| **INSTALLATION CHART: air conditioning systems for commercial properties.** | false ceiling depth | plant room/ roof space | service shafts | sill heights | electrical distribution | water pipework distribution | refrigerant pipework distribution | in-space refrigerant volume |
|---|---|---|---|---|---|---|---|---|
| **1.** VAV with perimeter heating | ■ | ▲ | ■ | ● | ● | ■ | ● | ● |
| **2.** VAV dual conduit | ▲ | ▲ | ▲ | ● | ● | ● | ● | ● |
| **3.** Moduline VAV with reheat | ■ | ▲ | ■ | ● | ● | ■ | ● | ● |
| **4.** Underfloor VAV | ● | ▲ | ■ | ■ | ● | ● | ● | ● |
| **5.** Modubox VAV with reheat | ■ | ▲ | ■ | ● | ● | ■ | ● | ● |
| **6.** VAV with reheat - floor by floor | ■ | ▲ | ● | ● | ■ | ■ | ● | ● |
| **7.** Fan powered mixing box | ▲ | ▲ | ■ | ● | ■ | ■ | ● | ● |
| **8.** Fan powered VVT | ▲ | ▲ | ■ | ● | ▲ | ■ | ● | ● |
| **9.** ATM VAV fan coil - vertical | ● | ● | ● | ● | ■ | ■ | ● | ● |
| **10.** ATM VAV fan coil - horizontal | ▲ | ● | ● | ● | ■ | ■ | ● | ● |
| **11.** Hydronic cassette | ▲ | ● | ● | ● | ■ | ▲ | ● | ● |
| **12.** Vertical fan coil | ● | ● | ● | ▲ | ■ | ▲ | ● | ● |
| **13.** Vertical perimeter heat pump | ● | ● | ● | ▲ | ▲ | ▲ | ■ | ▲ |
| **14.** Horizontal heat pump | ▲ | ● | ● | ● | ▲ | ▲ | ■ | ▲ |
| **15.** Variable volume/temp system | ■ | ■ | ▲ | ● | ■ | ● | ● | ● |
| **16.** VAVVT. | ■ | ■ | ▲ | ■ | ■ | ● | ● | ● |
| **17.** Vertical induction | ● | ■ | ● | ▲ | ● | ▲ | ● | ● |
| **18.** PTAC | ● | ● | ● | ▲ | ▲ | ● | ● | ▲ |
| **20.** Roof mounted package | ■ | ▲ | ▲ | ● | ● | ● | ● | ● |
| **21.** The multiple split air conditioner | ▲ | ▲ | ● | ■ | ▲ | ● | ▲ | ▲ |
| **22.** The district cooling system | ■ | ▲ | ■ | ■ | ▲ | ▲ | ● | ● |
| **23.** Ducted system | ■ | ▲ | ▲ | ● | ■ | ● | ● | ● |

# Moduline - a popular choice

No single air conditioning system is the best for all offices, but Carrier's variable air volume system - Moduline - is still the most popular choice for new and refurbishment projects, in both owner occupier and tenanted blocks.

Compared to traditional constant volume systems, VAV has low operating costs which stem from the inbuilt energy efficiency of the system design.

Since the Carrier Moduline system gives maximum lettable or usable floor area, good partition flexibility and incidentally a low installed cost, it is not difficult to appreciate its popularity. Indeed, for any building with sufficient floor to ceiling heights to accommodate the air distribution hardware above suspended ceilings, consideration of a Moduline system is a must.

The great attraction of VAV is that it is self regulating, i.e. each air terminal regulates its own air supply to control the temperature. High activity areas receive more air, while low activity areas are fed less. Indeed, vacant areas can be cut off entirely.

As a meeting room fills, or empties, with people or as the sun swings to another side of the building, so the Moduline units adjust themselves automatically. And since around one half of air conditioning energy consumption is used in moving the air, this system is inherently outstandingly energy efficient.

To meet the needs of many modern buildings, Moduline can now be linked to a BMS system by incorporating fully addressable electronic controls.

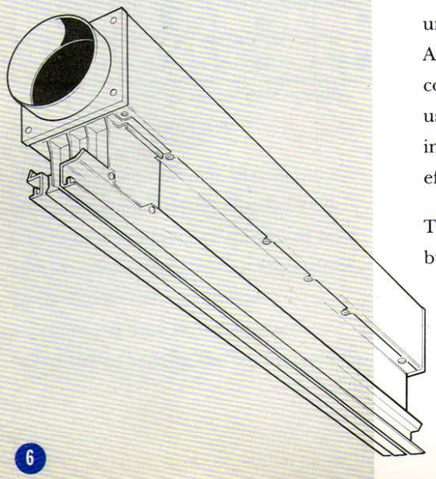
There are three basic Moduline systems, which are described later, but all of them deliver the right amount of cooling or heating wherever and whenever it is needed, with even air distribution without cold spots or draughts.

Since smaller cooling components are needed because full capacity is not required throughout the building, capital plant costs are lower than with equivalent constant volume systems.

As far as a developer is concerned, with a multi-tenanted block, there is the option to install the central cooling plant and then progressively fit the VAV terminals as and when the different sections of the building are leased. This has two advantages. The first is that there is no need to operate the system for the entire block when it is only partly occupied. The second is that it delays some capital outlay until such time as income is assured.

Moduline offers all these advantages to owners and tenants alike, whilst being the nearest thing that an air conditioning system can be to being aesthetically pleasing. It's almost invisible!

The Moduline air diffusers fit unobtrusively into standard suspended ceilings, looking much like the T-bar support structure. And in response to modern aesthetic requirements, square Moduline diffusers (either 500mm or 600mm square) offer added choice to design professionals seeking an alternative to the traditional linear diffuser.



The design of the Moduline system is such that if the occupier wants a major reorganisation of office layout, or introduces extra people or increased cooling requirement for a new concentration of office equipment for example, adjustments to existing Moduline units are simplicity itself.

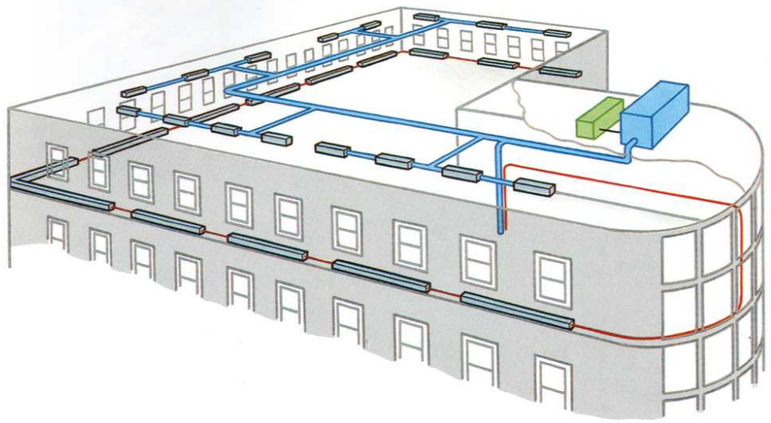
Finally, whereas every air conditioning system requires proper planned maintenance, the Carrier VAV system needs less than most.

## 1. Variable air volume with perimeter heating

Single plenum "Moduline" units are installed in the ceiling and chilled air is ducted to them. The perimeter heating system can take the form of radiators, convectors, or sill-line heating strips.

The central plant comprises boilers and refrigeration equipment, together with air handling units. There are several alternative plant configurations, depending on the size of the project and the physical constraints on the interior of the building.

* This system can be used with square Moduline diffusers as well as the linear models shown.



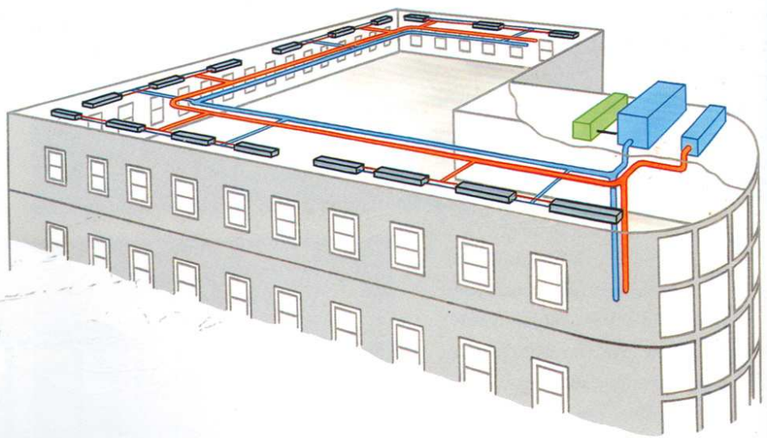
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ● |
| Maximum inspace flexibility | ● | Ease of maintenance | ● |
| Lowest operating costs | ● | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 2. Variable air volume dual conduit

Split plenum "Moduline" units are installed in ceilings at the perimeter of the building. Two ductwork systems, one supplying chilled air and the other heated, are connected to these units; the warm air is discharged towards the windows and the cold towards internal areas.

There is the additional option of air-to-water heat pumps, to provide seasonal heating and cooling. The central plant is similar to that in 1, above, but has a dual duct system.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ● |
| Maximum inspace flexibility | ● | Ease of maintenance | ● |
| Lowest operating costs | ● | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

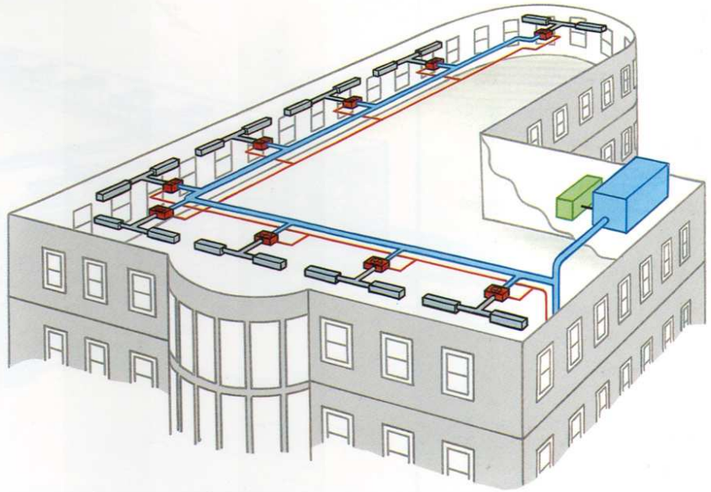
VERY GOOD ● GOOD ■ AVERAGE ▲

## 3. Moduline variable air volume with reheat

Single plenum "Moduline" units are installed in the ceiling void at the perimeter of the building. Chilled air is ducted to the Moduline units via a local reheat coil which is used as required to maintain room conditions.

Central plant is similar to 1.

* This system can be used with square Moduline diffusers as well as the linear models shown.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ● | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

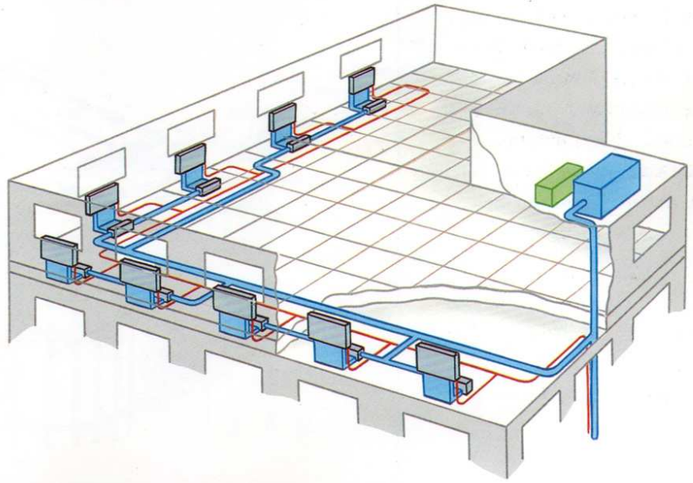
VERY GOOD ● GOOD ■ AVERAGE ▲

## 4. Underfloor variable air volume

Single plenum "Moduline" units are installed in the floor void and ducted to a perimeter discharge stack. Chilled air is then ducted to the Moduline units and reheated as necessary to maintain desired room conditions.

Reheating may be achieved either by the provision of a heater coil on the inlet to the Moduline plenum or by the utilisation of a radiant panel as the discharge stack.

The central plant is similar to that in 1.

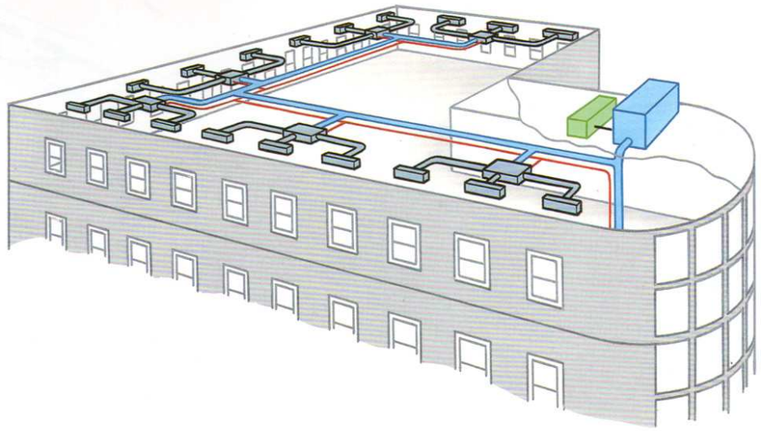


| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ■ | Durability of equipment | ■ |
| Maximum inspace flexibility | ● | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 5. Modubox variable air volume with reheat

Single plenum "Modubox" units are installed in the ceiling, with those at the perimeter fitted with electric or hot water heating coils. Chilled air is ducted to all "Modubox" units and then reheated, as required to maintain room conditions, and then distributed to ceiling mounted Moduboot diffusers. Central plant is similar to that in 1.

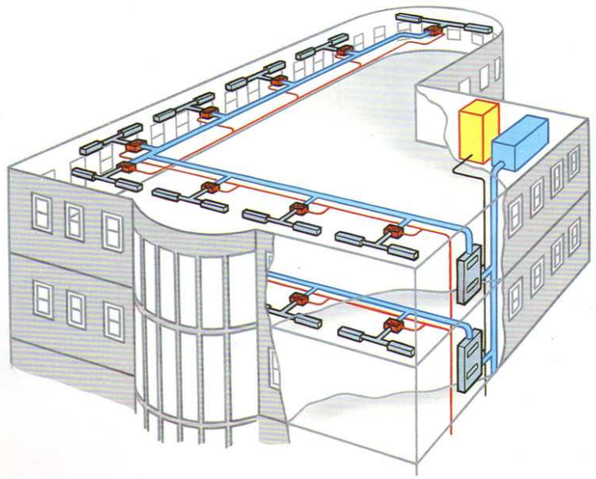


| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ▲ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 6. VAV with reheat - floor by floor

Single plenum "Moduline" units are installed in the ceiling void at the perimeter of the building. Chilled air is ducted to the Moduline units via a local reheat coil which is used, as required, to maintain room conditions. For this system the air handling unit is located on the served floor with the refrigeration and boiler plant, located centrally.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ■ | Durability of equipment | ● |
| Maximum inspace flexibility | ● | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲



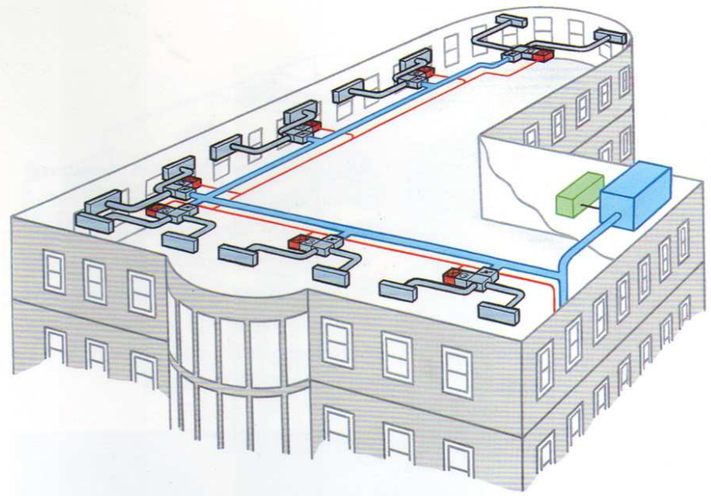


## 7. Fan powered mixing box

Parallel/side pocket fan powered mixing box units are installed above the ceiling. Chilled air is supplied from the central plant to the fan powered mixing boxes and ducted to "Moduboot" diffusers during the cooling cycle.

In the heating cycle, the mixing box fan is activated to draw warm ceiling plenum air across a reheat coil into the mixing box, adding heat from the reheat coil if required. The heated air is then ducted to the "Moduboot" diffusers. Control is achieved by the mixture of cold air and warm air to suit room conditions.

These units are also available in a series configuration. The central plant is similar to that in 1.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ▲ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ▲ |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ■ | | |

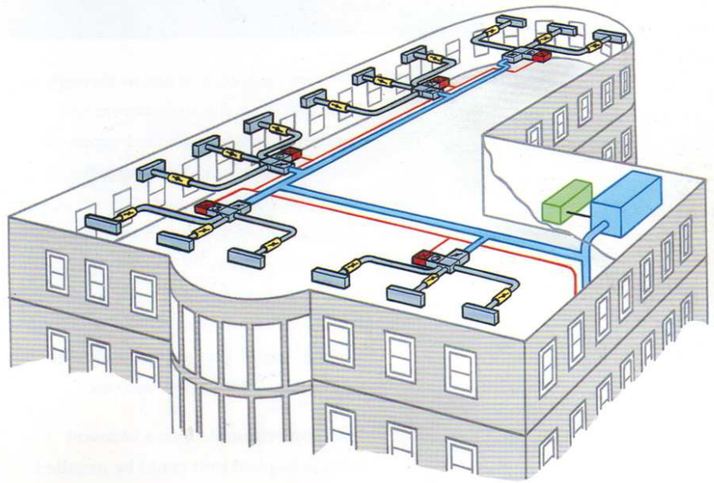
VERY GOOD ● GOOD ■ AVERAGE ▲

## 8. Fan powered VVT

Chilled air is supplied from the central plant to in-ceiling fan powered mixing boxes and ducted to the "Moduboot" diffusers via VVT Zone Dampers. Control of these dampers is achieved using zone thermostats.

In the heating cycle the mixing box fan is activated to draw warm ceiling plenum air across a reheat coil into the mixing box, adding heat from the reheat coil if required. During the cycle, control can be achieved by mixing cold and warm air in the mixing box.

The central plant is similar to that in 1.

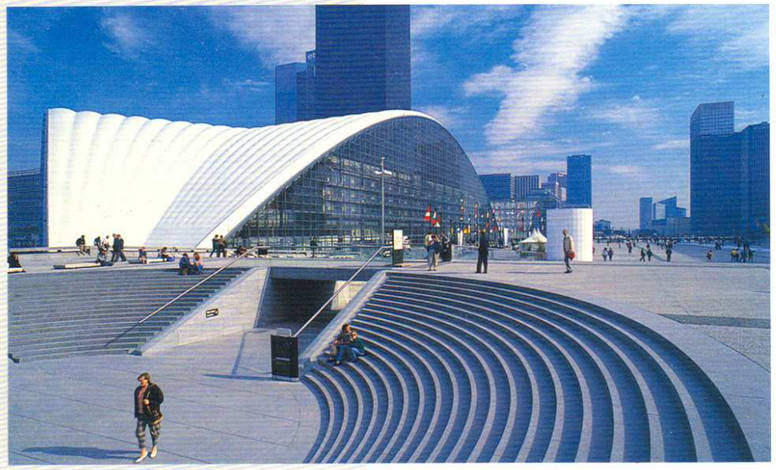


| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ● | Ease of maintenance | ■ |
| Lowest operating costs | ● | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ■ |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

# The ATM zonal fan coil

Combining the advantages of a fan coil system with the flexibility of VAV, the Carrier ATM (air treatment module) is a zonal fan coil designed to heat or cool individual zones or offices with self contained supply and return ductwork, providing a dedicated loop for each remotely sited ATM unit.



Air from each zone is drawn through a high efficiency filtration system and combined with a controlled supply of fresh air. This limits the possibility of cross contamination and removes all fan coil maintenance from the occupied area. In addition, the ATM has a variable air flow, and automatically modifies the volume of air circulated if, for instance, there is a large group of people in an office or if activity levels increase.

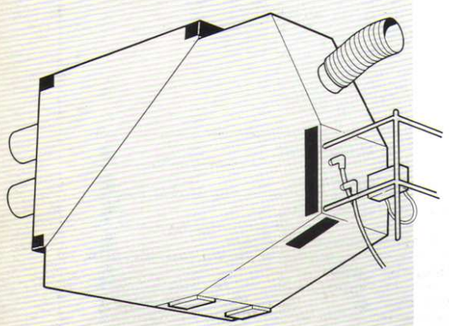
For simpler installations a constant volume 3-speed unit could be installed, with consequent reduction in capital outlay.

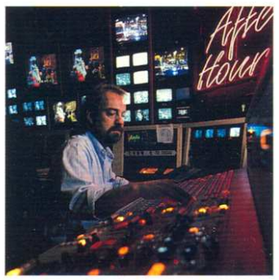
Each office has its own thermostat, enabling occupiers to adjust the room temperature according to personal preference. With the aid of a small desk top remote control panel, the occupier can, without moving from his seat, adjust the room temperature.

A central management system may also be installed to monitor and supervise the ATM network, so that although each person retains independent control of his own environment, within parameters determined by the central system, rescheduling of control setpoints and correcting misfunctions can be effected remotely.

All that is visible is the ceiling-mounted slot diffuser which fits unobtrusively into the standard suspended ceiling. Noise levels are minimal as the fan coils are located, floor by floor, in a communal plant room which may also house drainage stacks, hot and cold water services, fresh air ductwork and so on, thereby freeing up the maximum lettable area.

An additional benefit is that service work can be carried out without disturbing the building's occupants. Similarly, ATM's modular construction means that either an individual part can be changed in seconds, or a complete ATM unit can be quickly replaced with a spare. Combined with the remote monitoring facility, is it any wonder that maintenance costs for the ATM system are so low?







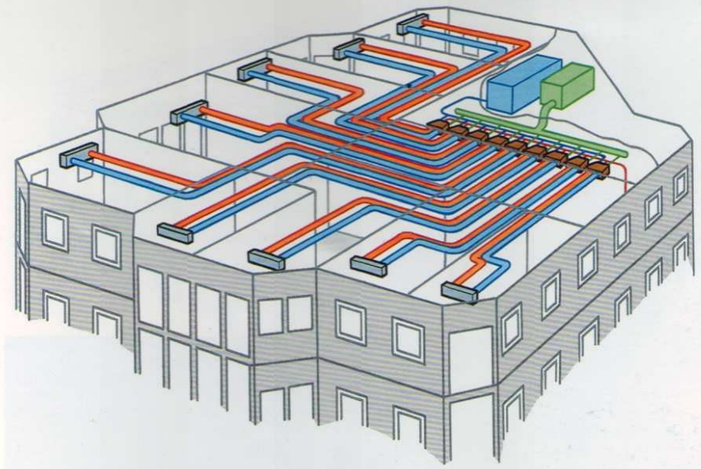



## 9. ATM VAV fan coil - vertical

ATM fan coils are installed at high level in a central plant area where recirculated air is mixed with filtered outdoor air for supply to individual zones.

Individual remote control panels, combining all environmental control functions enable each occupant to control his own environment. Minimum plant room space is required and its central location ensures ease of maintenance.

The central plant comprises outdoor air treatment plant, refrigeration equipment and boilers.



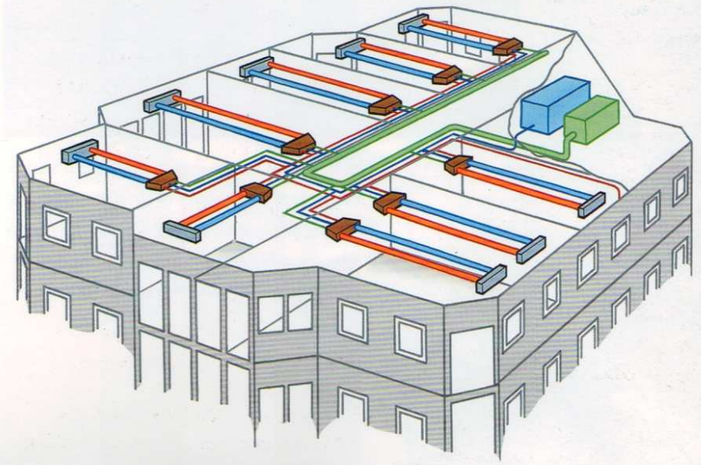
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ● | Ease of maintenance | ● |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ● | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 10. ATM VAV fan coil - horizontal

ATM fan coils are installed in false ceilings or in bulkheads where recirculated air is mixed with filtered outdoor air for supply to individual zones. The high static fans enable the units to be installed outside the occupied area for ease of maintenance and for quiet operation.

Individual remote control panels allow the occupant to control his/her own environment. The central plant is similar to 9 above.

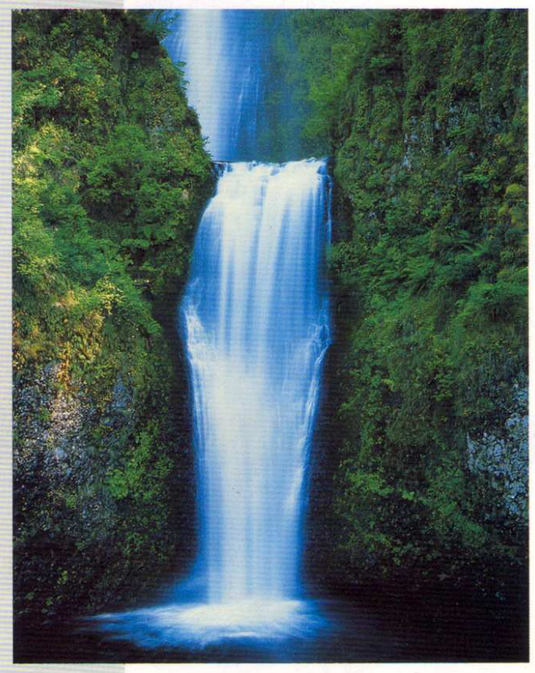


| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ▲ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ● |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

# Hydronic systems

When considering the various air conditioning options, the recommendations of BS 4434 will certainly influence the choice of building developers, owners and premises managers.



In addition to the ecological implications, the potential dangers of refrigerant leaks within multi split air conditioning systems or in installations with remote air cooled condensers are now being recognised.

As a safety measure, in large systems where the loss of refrigerant gas could be considerable, BS 4434 may well advise the need for specially ventilated ducts in certain areas to carry the refrigerant pipes. This will add significantly to the cost of the installation.

One solution is the installation of chilled water systems which limit the amount of refrigerant in the building.

Instead of refrigerant, hydronic air conditioning systems use either chilled water for cooling or warm water for heating in the connecting pipes between the fan coil unit and the water chiller or heat pump. Overall, up to 80% less refrigerant is needed and even this is contained within the chiller or heat pump in a circuit which is hermetically sealed and leak tested at the factory. This system stays sealed during installation, start up and operation.

Hydronic systems are infinitely flexible and can be easily adapted to increased capacity requirements without disturbing the refrigerant circuit or dismantling in-space refrigerant pipework - an important factor when a building undergoes a change of use or requires a different layout.

In our increasingly ecologically aware world, the hydronic system cannot provide all the answers but it offers one solution to a particular problem. Water is simple to use, control and distribute and will not harm our environment.

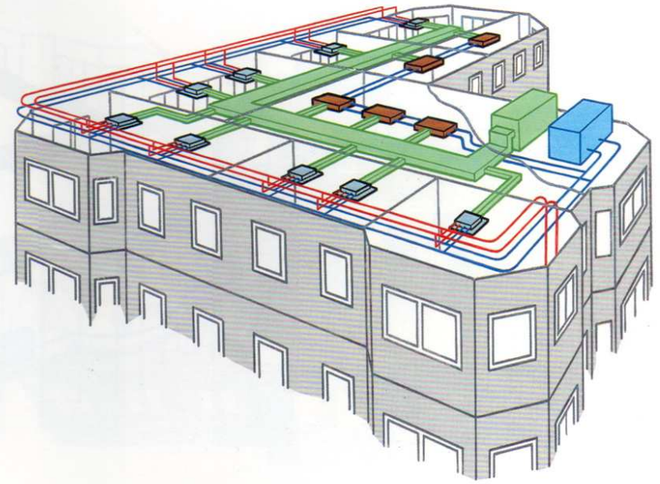




## 11. Hydronic cassette and horizontal fan coil

Fan coils are installed in the false ceiling where they are supplied with hot and chilled water from centrally located boilers and refrigeration plant. A separate air handling unit introduces outdoor air directly into the unit for ventilation.

Locally mounted controls sequence the heating and cooling to maintain the desired room condition.



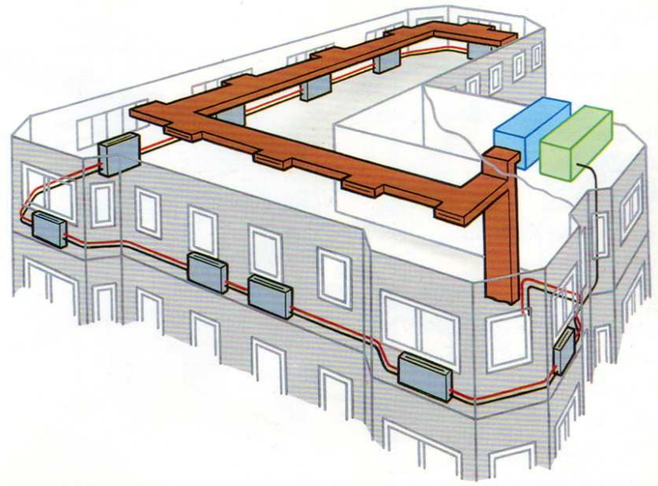
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ▲ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ▲ |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ▲ |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 12. Vertical fan coil

Fan coils are installed under window sills around the perimeter of the building. They are supplied with hot and cold water from centrally located boilers and refrigeration plant. Separate air handling units introduce fresh air for ventilation.

Locally mounted thermostats sequence the heating and cooling to maintain desired room conditions. This system also allows for the incorporation of air-to-water heat pumps to provide seasonal heating and cooling.



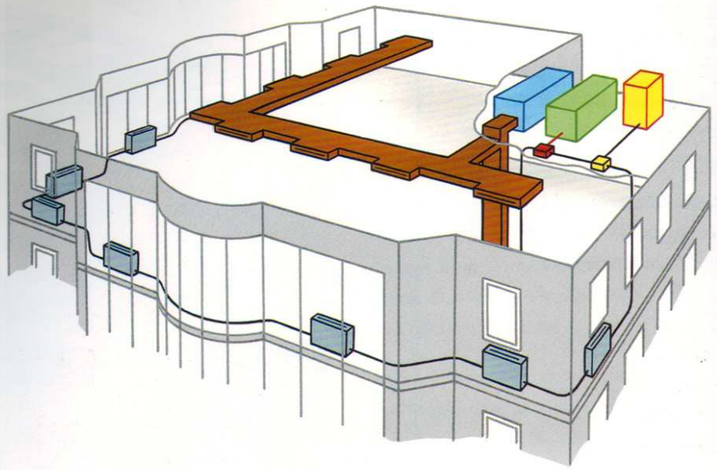
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ▲ | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ▲ |
| Compatibility with aesthetic requirements | ▲ | Indoor air quality | ▲ |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 13. Vertical perimeter heat pump

This is a reverse-cycle console unit containing a complete refrigeration circuit which operates in either heating or cooling mode dependent on room conditions.

The central plant comprises boilers and cooling towers. These, via a water loop, provide the heat pumps with a constant source of controlled temperature water which acts either as a source of heat or a means of rejecting heat. There is the possibility of incorporating air-to-water heat pumps in place of a boiler.

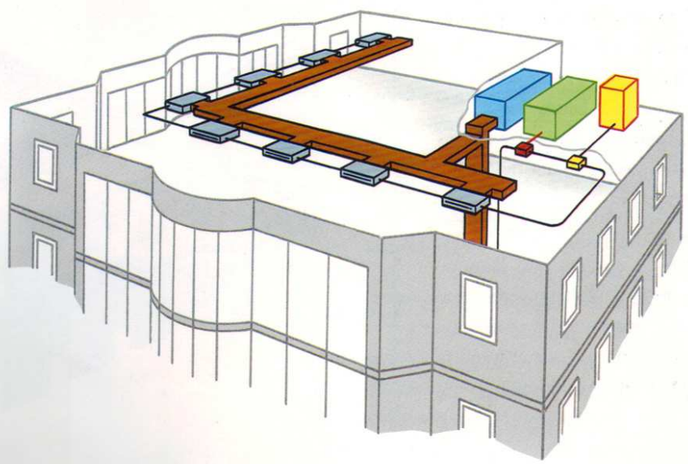


| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ▲ | Durability of equipment | ■ |
| Maximum in-space flexibility | ■ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ■ |
| Compatibility with aesthetic requirements | ▲ | Indoor air quality | ▲ |
| Room sound levels | ■ | VERY GOOD ● GOOD ■ AVERAGE ▲ | |

## 14. Horizontal heat pump

This is an above ceiling mounted reverse cycle unit containing a complete refrigeration circuit which operates in either heating or cooling mode, dependent upon room requirements. Air is discharged into the room via suitable diffusers.

The central plant comprises boilers and cooling towers. These, via a water loop, provide the heat pumps with a constant source of controlled temperature water which acts either as a source of heat or a means of rejecting heat. There is the possibility of incorporating air-to-water heat pumps in place of a boiler.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ▲ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ▲ |
| Room sound levels | ■ | VERY GOOD ● GOOD ■ AVERAGE ▲ | |

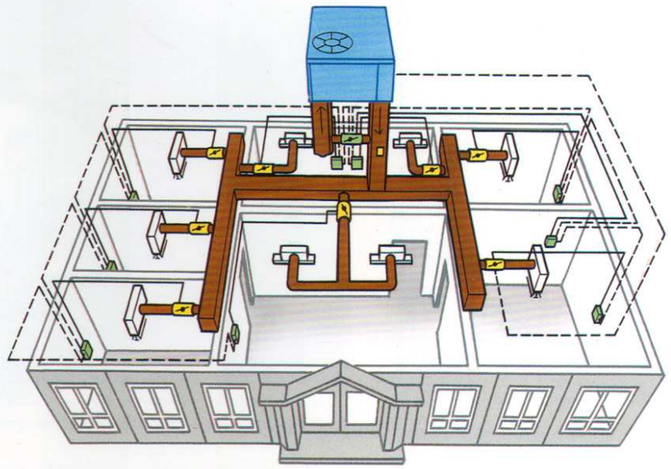




## 15. Variable volume/variable temperature system

A single or split package heating and/or cooling unit is combined with locally mounted dampers and room thermostats to form the variable volume/variable temperature system.

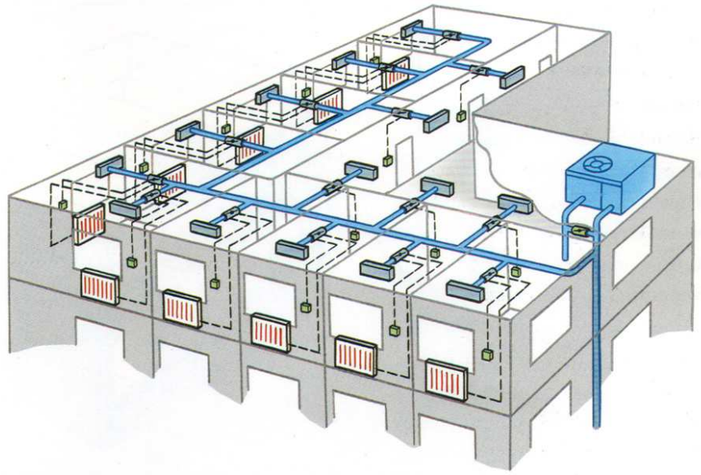
In each zone air volume and temperature are both varied to produce the desired comfort conditions. Even when cooling and heating are called for simultaneously the single package hvac unit can satisfy each demand in turn. Air from the hvac unit is ducted to the Moduboot diffusers via the individual zone dampers.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ● |
| Maximum inspace flexibility | ● | Ease of maintenance | ■ |
| Lowest operating costs | ● | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ▲ |
| Room sound levels | ● | VERY GOOD ● GOOD ■ AVERAGE ▲ | |

## 16. VAVVT

Combining VAV and VVT control logic, the central plant is similar to 15 above. In addition, each perimeter zone has a heating source, ie duct mounted coil, hot water radiators or electric heaters as required. This is automatically enabled and controlled on a zone by zone basis when the ambient falls below a predetermined level. Simultaneously central areas can use cooling if required. At temperatures above this predetermined level perimeter heating is locked out.



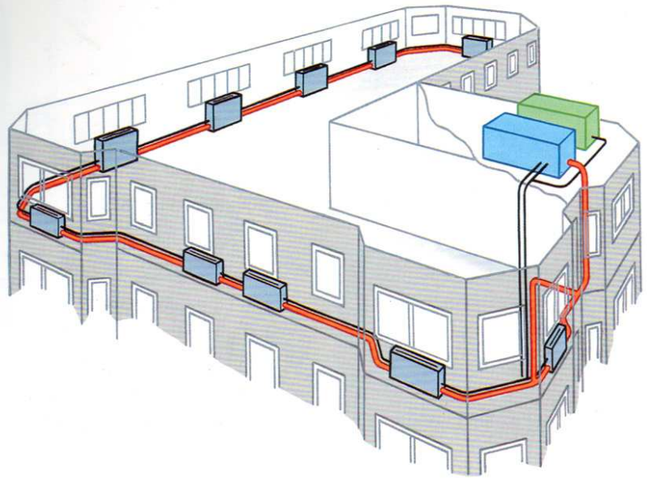
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ■ | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ● | Lowest environmental impact | ● |
| Compatibility with aesthetic requirements | ● | Indoor air quality | ■ |
| Room sound levels | ● | VERY GOOD ● GOOD ■ AVERAGE ▲ | |

## 17. Vertical induction

Induction units are installed under window sills around the internal perimeter of the building. These are usually supplied with chilled water and high pressure air which is warmed or cooled to provide heating or cooling as required.

The central plant comprises boilers and refrigeration equipment, together with high-pressure air handling units. Air-to-water heat pumps can be included to provide seasonal heating and cooling, in conjunction with a storage tank.

* This system is also available in a horizontal configuration.



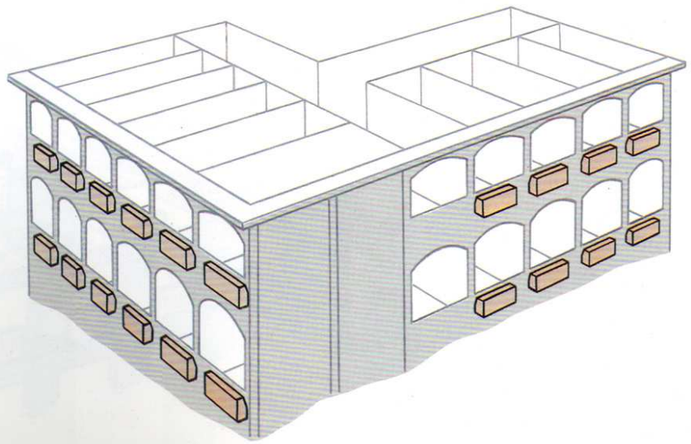
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ▲ | Durability of equipment | ■ |
| Maximum in-space flexibility | ■ | Ease of maintenance | ● |
| Lowest operating costs | ▲ | Localised control options | ■ |
| Comfortable working environment | ■ | Lowest environmental impact | ▲ |
| Compatibility with aesthetic requirements | ▲ | Indoor air quality | ■ |
| Room sound levels | ■ | VERY GOOD ● GOOD ■ | AVERAGE ▲ |

## 18. Packaged Terminal Air Conditioner

Ideal for hotels and offices as well, these units are packaged, self contained cooling and heating units. They are through the wall packages mounted at low level.

Individual unit controls combine all the necessary control functions for each occupant to control their own environment. Electric heating can be provided so no external water or refrigerant pipework is necessary.

No plant space is required with these units. Heat pump versions are available for increased energy efficiency.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ▲ | Durability of equipment | ■ |
| Maximum inspace flexibility | ▲ | Ease of maintenance | ■ |
| Lowest operating costs | ▲ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ■ |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ▲ |
| Room sound levels | ▲ | VERY GOOD ● GOOD ■ | AVERAGE ▲ |





## 19. Ice thermal storage systems

Ice storage is a system used to take advantage of the lower night time electricity tariffs and/or allow the use of smaller refrigeration plant than that required to cope with peak cooling loads.

A centrally located ice storage bank is cooled out of normal hours by the central refrigeration plant. When cooling is required chilled glycol or brine is passed from the ice storage vessel to the air handling systems. The refrigeration plant can also provide supplementary cooling as required.

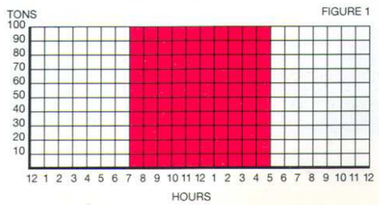
Because of the low brine temperatures possible with this type of system, low temperature supply all air systems can be installed in the buildings resulting in possible smaller distribution ductwork.

A number of systems are available to achieve this type of installation. For example, the Carrier Distributed Reaction Thermal Encapsulated Ice Store is fully compatible with air or water cooled machines. It uses multiple ice lenses which freeze and expand when the brine solution circulates around the polythene containers or lenses, so creating the ice storage effect. The volume of storage in the ice module container is governed by the number of lenses used. As the Reaction Ice Storage is a closed circuit system, no heat exchangers are normally used.

**Method of Operation**

In conventional air conditioning system design, cooling loads are measured in terms of "Tons of Refrigeration" required. Stored Cooling Systems, however, are measured by "Ton-Hours."

**FIGURE 1** represents a theoretical cooling load of 1,000 hours being 100 tons maintained for 10 hours. Each 10 ton-hour period is represented by one square in the diagram.



*The Aldermanbury Development, London which has an ice storage system. Consultants: The Brian Warwicker Partnership.*

No building air conditioning system operates at 100 percent capacity for the entire daily cooling cycle.

**FIGURE 2** represents a typical building air conditioning load profile during a design day. The full 100 ton chiller capacity is needed for only two of the ten hours in the cooling cycle. If you count the tinted squares, it will total 75 squares, indicating a true cooling load of 750 ton-hours. A 100 ton chiller must be specified, however, to handle the peak 100 ton cooling load.

In new construction, a Partial Storage System is the most cost effective load management strategy. In this load-levelling method, the chiller runs continuously. It charges the ice storage at night and cools the load directly during the day with help from stored cooling.

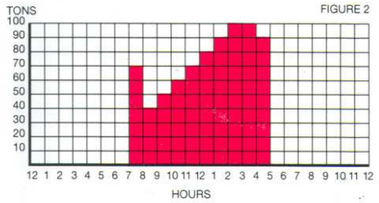
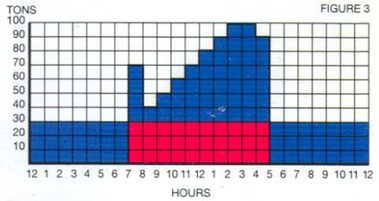
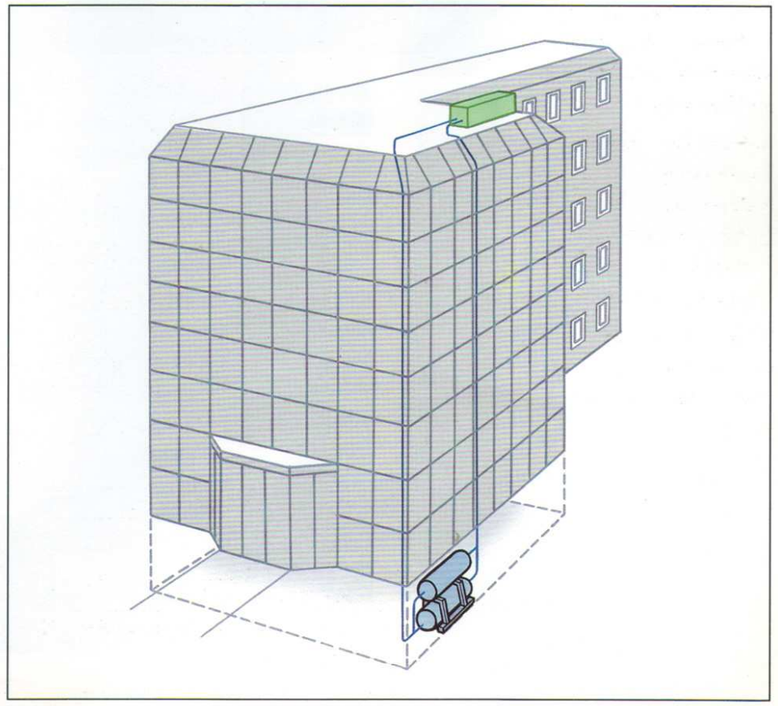



**FIGURE 3** shows that by extending the hours of operation from 14 to 24 results in the lowest possible average load (750 ton-hours divided by 24 = 31.25). Demand charges are greatly decreased and chiller capacity can often be reduced by 50 to 60% or more.

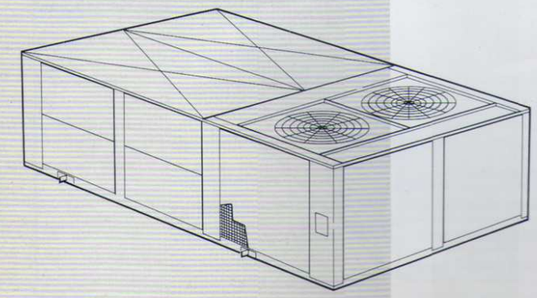


# Air conditioning solutions to retail needs

Customers expect to shop in comfort, and retailers know the importance of ensuring an attractive, welcoming environment inside their stores. Individual specialist shops, high street multiples, department stores and entire shopping centres all have to keep up with the times to retain the loyalty of their clientele, provide comfortable working conditions for staff and minimise stock spoilage. And that means choosing the right air conditioning system is every bit as important in the retail sector as in the commercial office market.

However, the selection of air conditioning systems presents special challenges for retail businesses. With heavy basic outgoings in rents and rates, managements demand guarantees of low overheads elsewhere and are very energy conscious.

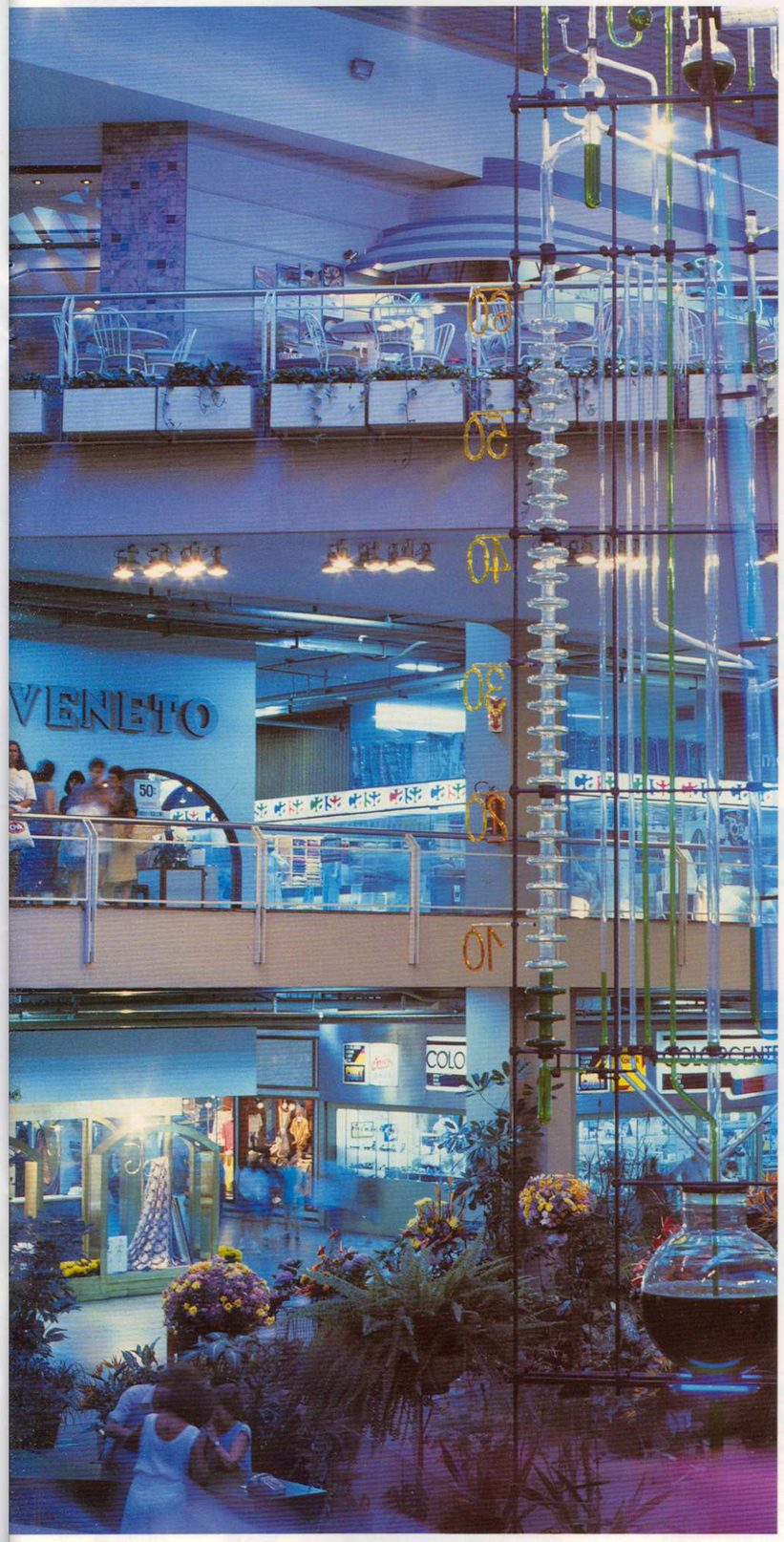


Many shopping centres and malls built in the 1960's are now being refurbished in order to compete for custom with new retail developments. The vast majority are being roofed over with vaulted glass panels, making the installation of effective air conditioning an absolute necessity if they are to continue to be attractive places to shop in, retain the loyalty of retailers and prove satisfactory investments for their owners into the 21st century. However, the refurbishment of services brings its own challenges.

It is vital to retain trading activity with minimal inconvenience to customers. Work must be carefully phased and efficiently carried out by a company sympathetic to the trader's business needs. As a result, an increasingly attractive option for air conditioning both new and existing centres and department stores is the installation of a large roof-mounted packaged air conditioner.

If capital expenditure is of critical importance, department stores and similar large retail outlets can be progressively air conditioned, one department at a time, to suit both trading requirements and the availability of finance. This will normally involve the use of self-contained packaged systems, tailored to meet the needs of the areas being conditioned.

An alternative solution for refurbishment of shopping centres involves a remotely-located central chiller plant supplying a cooling ring main, with individual air handlers to supply and extract the conditioned air from individual shops or communal areas. A BMS interface for remote monitoring of the equipment can be provided.




Small multiple split systems often offer the ideal solution for small speciality outlets, either at fit-out stage or as a retrofit to reflect increased trading success by providing a comfortable internal environment for their customers.

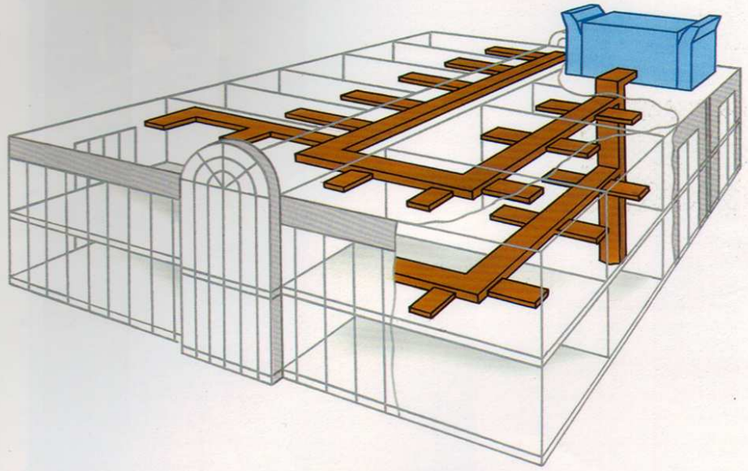
Many of the systems described here, may also be applied to various types of office development.

## 20. The rooftop air conditioning package

The Carrier roof mounted package is ideal for larger retail outlets or commercial office developments. It supplies chilled or heated air through a ducted system to the air supply diffusers.

If there is no standard unit to match your needs, the ideal solution is to order a custom built package to match the design requirements exactly.

These packages have the added advantage in that they meet the time sensitive demands of the refurbishment and new build sectors, and fulfil the growing demand for larger air conditioning capacities within a single unit. Once lowered into position, they require only electrical and ductwork connections to make them operational and ready for final system commissioning.Whether standard or customised, the units are available as cooling only or in heat pump configuration.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ■ |
| Maximum inspace flexibility | ▲ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ■ |
| Comfortable working environment | ■ | Lowest environmental impact | ▲ |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ● |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

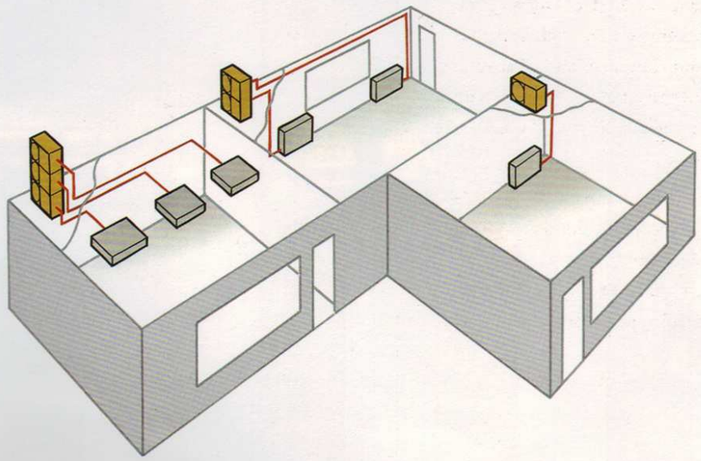
## 21. The multiple split air conditioner

This system is suitable for smaller retail outlets and individual offices. A split room air conditioner, having either wall, floor or ceiling mounted fan coil units linked to the external refrigeration section provides heating and cooling.

These splits can be used individually in smaller retail outlets or single offices, or several splits can be used to feed separate areas or departments in larger retail operations.

Each indoor unit, whether installed singly or as part of a triple split system, is linked to its own dedicated condensing unit. This limits the volume of in-space refrigerant to within the safety guidelines set by BS 4434.

Indoor units are available in a wide variety of configurations to fit all applications.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ■ | Durability of equipment | ■ |
| Maximum in-space flexibility | ▲ | Ease of maintenance | ▲ |
| Lowest operating costs | ■ | Localised control options | ● |
| Comfortable working environment | ■ | Lowest environmental impact | ▲ |
| Compatibility with aesthetic requirements | ▲ | Indoor air quality | ■ |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

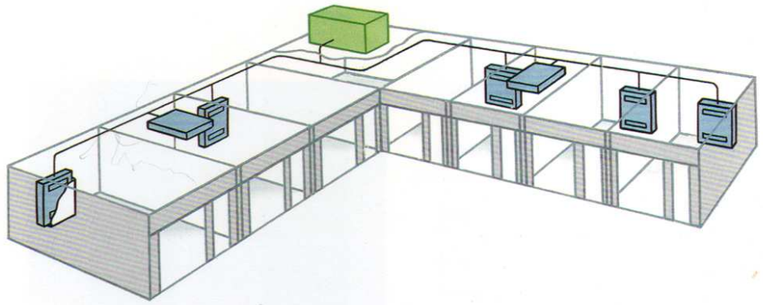




## 22. The district cooling system

This concept is ideal for shopping centres. A remotely located refrigeration plant feeds chilled water into a ring main running around the shopping centre.

Each retail unit then has the option of installing its own fan coil units and linking into the "ring main" for a source of cooling.



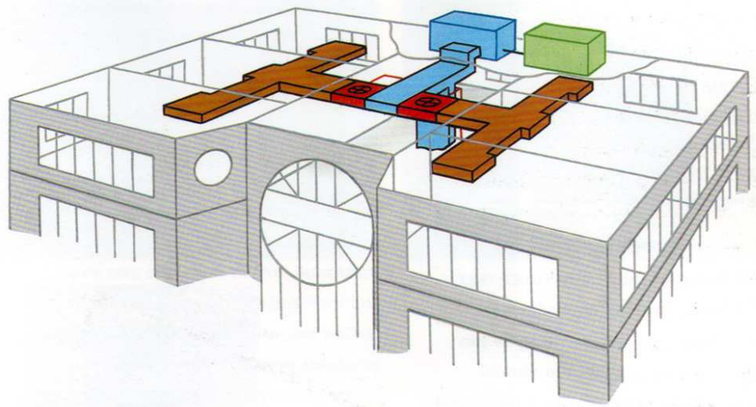
| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ■ | Durability of equipment | ■ |
| Maximum inspace flexibility | ■ | Ease of maintenance | ■ |
| Lowest operating costs | ■ | Localised control options | ■ |
| Comfortable working environment | ■ | Lowest environmental impact | ■ |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ■ |
| Room sound levels | ■ | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

## 23. Ducted system

A central plant room, internally or externally located, comprising an air handling unit and chillers. A constant volume of air is distributed around the building through a duct system and supplied to the space via diffusers.

This type of system has been largely superseded due to its lack of flexibility and high operating costs. However, it still has a role to play for specific applications.



| | | | |
|---|---|---|---|
| Maximum usable/lettable floor space | ● | Durability of equipment | ● |
| Maximum inspace flexibility | ▲ | Ease of maintenance | ● |
| Lowest operating costs | ▲ | Localised control options | ▲ |
| Comfortable working environment | ● | Lowest environmental impact | ■ |
| Compatibility with aesthetic requirements | ■ | Indoor air quality | ■ |
| Room sound levels | ● | | |

VERY GOOD ● GOOD ■ AVERAGE ▲

# Computer aided design for the future

A sophisticated air conditioning system is precision designed to provide total control over the environment. As such, it needs to be specified and installed correctly to ensure client satisfaction and maximum economic efficiency in use.

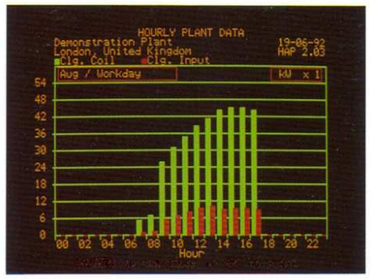
As computer technology advances in leaps and bounds, so building services engineers and other construction industry professionals are more able to accurately evaluate the various alternatives as they strive for optimum design.

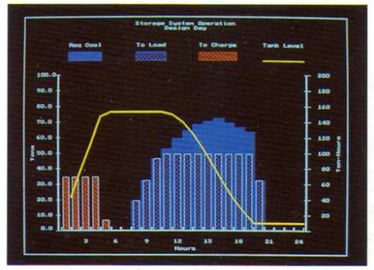
Carrier's E20-II HVAC design package is the ideal design tool for the building services engineer.

The tasks that E20-II currently performs include:

- Cooling Load Estimates (ASHRAE Transfer Function & Carrier Methods)
- Heating Load Estimates (ASHRAE & Carrier Methods)
- Air Duct Sizing, Balancing, Material Estimating etc
- Refrigerant and Water Pipe Sizing
- Energy Analysis of System Designs & Building Running Costs
- Economic Analysis and ASCII File Transfer
- DuctLINK and LoadLINK - CAD Integrated Programmes

Carrier's Hourly Analysis Program (HAP) is a computer programme that estimates design cooling and heating loads for commercial buildings. It can also be used to compare the annual energy consumption and operating costs for alternative HVAC system designs.



### How HAP Works

First, information regarding the layout, construction and operation of the building must be entered along with climate data. Next, characteristics of the HVAC system are defined. This includes thermostat setpoints, equipment sizing criteria, and system operating characteristics.

Using this data, plus the building and climate information, the programme estimates peak cooling loads for the building for any range of months and hours desired. Maximum room loads, maximum airflow rates, the maximum coil load and the required central fan airflow rate are all identified. Calculation printouts provide sufficient information to size and select the various components of the HVAC system.

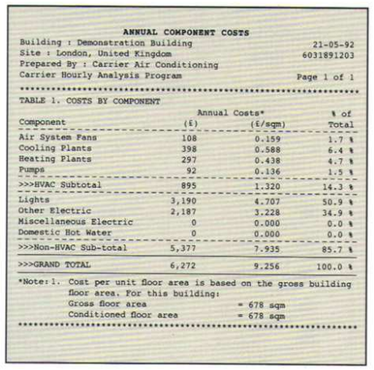
If desired, the programme can also compare the annual energy consumption and operating costs for system design alternatives. First, operating characteristics of the alternative HVAC systems are defined. Then, detailed hour-by-hour simulations of air system performance and plant operation are conducted to determine hourly and monthly energy consumption.

This energy consumption data is then used to determine annual operating costs. When needed, complex electric rate structures, including demand charges, can be considered. Finally, costs and energy results can be printed in a variety of useful tabular and graphical formats.

The HAP File Transfer Program is a Utility Program which is able to transfer information from the HAP Database to ASCII text files or Third Party Software such as Coolaid. Coolaid is specifically designed as an interactive screening tool to evaluate the cost impacts of cool storage systems in commercial buildings.

DuctLINK and LoadLINK are integrated packages that combine the design capabilities of E20-II with the draughting capabilities of AutoCAD.

All programmes utilise a modular, menu driven structure making them easy to use, and a user's manual contains operating instructions, documentation of calculations and example problems.



ANNUAL COMPONENT COSTS

Building : Demonstration Building — 21-05-92
Site : London, United Kingdom — 6031891203
Prepared By : Carrier Air Conditioning
Carrier Hourly Analysis Program — Page 1 of 1

TABLE 1. COSTS BY COMPONENT

| Component | Annual Costs* ($) | ($/sqm) | % of Total |
|---|---|---|---|
| Air System Fans | 108 | 0.159 | 1.7 % |
| Cooling Plants | 398 | 0.588 | 6.4 % |
| Heating Plants | 297 | 0.438 | 4.7 % |
| Pumps | 92 | 0.136 | 1.5 % |
| >>>HVAC Subtotal | 895 | 1.320 | 14.3 % |
| Lights | 3,190 | 4.707 | 50.9 % |
| Other Electric | 2,187 | 3.228 | 34.9 % |
| Miscellaneous Electric | 0 | 0.000 | 0.0 % |
| Domestic Hot Water | 0 | 0.000 | 0.0 % |
| >>>Non-HVAC Sub-total | 5,377 | 7.935 | 85.7 % |
| >>>GRAND TOTAL | 6,272 | 9.256 | 100.0 % |

*Note: 1. Cost per unit floor area is based on the gross building floor area. For this building:
Gross floor area = 678 sqm
Conditioned floor area = 678 sqm



# The world's finest range of air conditioning products

Carrier offers architects, developers, building owners, surveyors, engineers and space planning consultants an unparalleled range of air conditioning systems and products developed especially for the needs of the commercial property sector.

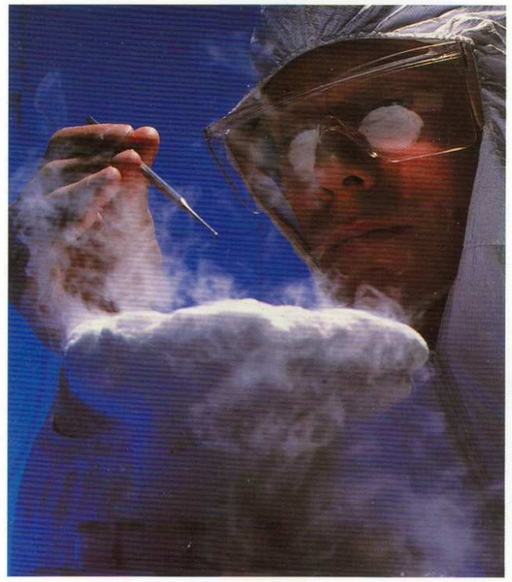
Each year, Carrier invests more than US$100 million on research and development carried out by almost 1,000 graduate engineers, scientists and technicians working in 19 design centres and laboratories around the world.

Carrier also draws upon the research arm of its parent company, United Technologies Corporation. With annual expenditures of more than a billion dollars, UTC is one of the top r&d investors in the US. Sustained research into key technologies - compression, heat transfer, electronics, air movement and refrigerant management - has two primary objectives.

The first is to generate new products, processes and systems designed to meet the increasingly complex environmental requirements of the buildings of today. The second is to subject established products to continuous examination, refinement and improvement.

So successful is Carrier's engineering development programme, that it holds more than half the worldwide patents on air conditioning products. In fact, there are over 10,000 different units in the Carrier product offering from which to select both the terminals and central plant that constitute every system, whatever its size or complexity.

From the largest centrifugal chiller to the smallest room air conditioner, whatever the constraints of any individual building or sector within a building, there is a Carrier product to suit.



*Carrier has a national network of branch offices staffed by highly trained and experienced engineers, and the address of your local branch may be found on the back page of this brochure.*