Pour in fresh air

Displacement ventilation systems are a simple, effective way of treating the indoor environment, Bill Ridoutt* explains the way they work and the advantages

When ventilating or air conditioning we used to think of the air as an indefatigable fluid which can be used almost indefinitely as long as there is the required proportion of fresh air. Recently, people have become more conscious of the actual condition of air, with increased reporting on "sick" buildings.

It is useful to use the analogy of water flow and interaction with its surroundings to describe the principles and application of airflow.

Use of water and air in the built environment can be thought of as parallel. We would never consider recirculating used water from say, a washing-up or washing machine straight back into the clean water supply. However, we frequently recirculate air which has been passed through the living space. This air can be re-used many times without treatment other than basic filtration.

Most ventilation systems are based on the mixing principle which means incoming fresh air is mixed with re-circulated air and sent back into the living space. This mixture of clean and dirty air is then circulated over and over again until it is finally extracted.

To maintain the best quality of air passing into the occupied space, air must be 100 per cent fresh rather than a poorer mixed condition.

Advantages with recirculation like energy conservation with a lower building heat load mean the development of a full fresh air design must aim to produce a similar energy efficiency.

■ Pollutants displaced

Again if we look at the water analogy; take a tank full of polluted water and introduce clean water at a temperature a few degrees below pouring slowly into the tank. The clean water flows to the bottom of the tank and runs along horizontally to create a clean water layer. The polluted water is displaced upwards, leaving a clean zone.

It is possible to give rise to the same effect with air. Clean, fresh air can be introduced at low levels and at a temperature slightly lower than the required room temperature. If the velocity of air leaving the terminals is low the air will move horizontally across the floor. When this air comes into contact with a heat source, natural buoyancy will produce an upward motion. This effect will take away heat and pollutants to above the living zone.

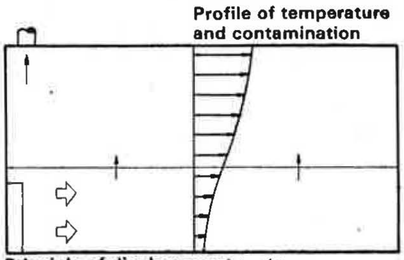
Polluted warm air can be extracted at high level from a single point and the heat recovered in heat exchangers. This energy can then be used to raise the temperature of the incoming air.

To take advantage of this displacement principle, there needs to be extensive empirical testing and the measurements must be collated into sizing and selection data.

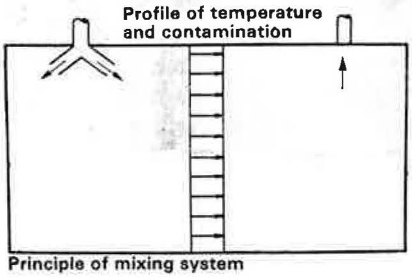
Important factors which govern the application of a ventilation system based on displacement are:

- Building heat load
- Vertical temperature gradient
- Mean temperature in occupied area
- Net power per unit flow
- Exhaust air temperature.

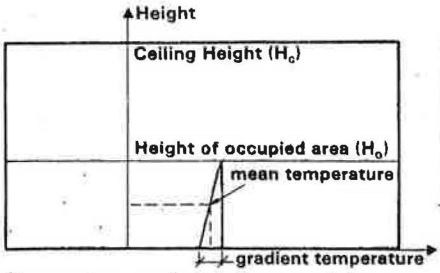
Laboratory tests show the effect of displacement ventilation: hot, dirty air is forced to the ceiling



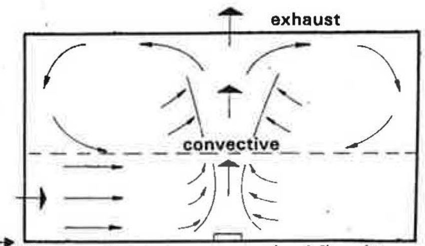
Principle of displacement system



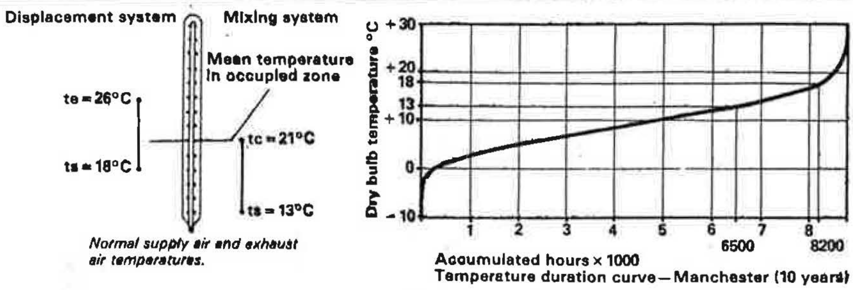
Principle of mixing system



Temperature gradient in the occupied area.



Cooperation between supply airflow in displacement system and convective flow.



Weather data show displacement system refrigeration plant will run less often.

This 100

The crucial parameter to ensure that the displacement principle applies is the difference in temperature between the air leaving the terminal and the final room temperature.

Buoyancy

There must be a small rise in temperature within the space to create the buoyancy effect necessary for effective opperation.

To design a displacement ventilation system, one must take the following steps:

- Establish the net power of the premises.

  Net power is defined as the difference between the amount of heat in the exhaust and the supply air to and from the building. Generally there is a surplus of heat energy and this is taken as a positive value. In winter there will be a heat demand, described as a negative net power.
- Determine the temperature in the occupied area.

  This will then be expressed by the client as a requirement. If this is not the case then reference to data for the type of activity taking place can be made.
- Vertical temperature gradient.

  The vertical temperature gradient will be dependent on the type of activity occurring within the space. Recommendations can be made for various occupations depending on the heat given off by personnel operating in the area.
- Supply air temperature.

  If the desired mean temperature in the occupied space and the recommended temperature gradient are known, the supply air temperature (ts) can be calculated. This is an empirical determination based on operational experience of the Floormaster system and gives the guidelines for ventilation design work.

Development of this system has taken more than ten years and thousands have been installed around the world. The design procedures outlined here are well documented and we can make accurate predictions about how systems will perform.

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Clean Glasgow air

Floormaster is in operation at a major Scottish newspaper company. Twenty-eight terminals were installed at George Outram and Co, Glasgow, in the new £2.5m extension to the company's print-works. These were installed in the Despatch, Inserting and Plate-making areas as well as the Press and Reel Halls.

The extension is part of a £22.5 million investment in new technology which includes the latest in colour presses and inserting equipment. The company is the publisher and printer of the 206-year-old Glasgow Herald.

Engineers awarded the mechanical services contract—Associated Consultancy & Technical Services (A.C.T.S.) of Clydebank—were faced with a number of ventilation problems.

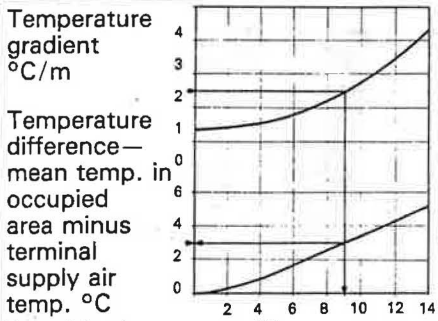
Presses generate heat of around 365kW and this heat is distributed over the length and height of the press.

A conventional air conditioning system could not be used as air blown downwards would result in dust damage or tearing of the paper web which weaves through the press. Initially A.C.T.S. thought they would have a larger number of high and low level grilles, spaced so as not to blow across the web.

But the company then found out about displacement ventilation. Clean fresh air is supplied at low level between 1°–5°C lower than the press room design temperatures. As the supply is at this temperature, it flows onto the floor and spreads evenly through the press room and occupied area. Surrounding air heated by the press is displaced by incoming cooler fresh air.

By using the Floormaster system large quantities of air were supplied through relatively few outlets at a low velocity.

Activity	Recommended temperature gradient °C/m
Sitting, light	1.5
Standing, light	2.0
Standing, medium	2.5
Standing, heavy	3.0



Determining the temperature difference and the net power per flow unit in W/(l/s)

Heatability

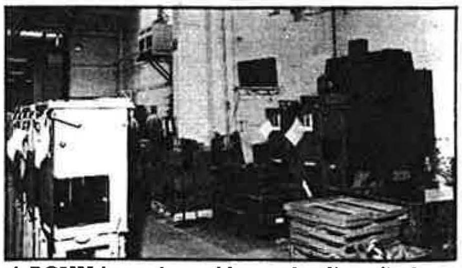
Variety in the type of buildings involved, and their use within the factory, were critical factors in the selection of heating equipment for high voltage switchgear manufacturer, Lond & Crawford, in Manchester.

At the company's factory, direct and indirect fired warm air heaters, radiant tubes and roof suspended gas unit heaters all figured in the new heating system designed and installed by mechanical and electrical services engineers, Downs Daley, for architects, Lomax & Gardiner (Altrincham). Plans to build a new factory extension of over 4,000m² on the site caused a reapraisal of the company's heating needs for the whole factory. The company indicated that manufacturing and assembly space was at a premium and that selected plant should occupy the minimum area.

Three Powrmatic DFU 750 direct-fired units, two externally-mounted and on horizontally-mounted, are used to heat the newly-constructed area, so operational floor space is kept free of plant. A fourth unit, an EA 800 indirect-fired heater is mounted on the outside wall of the building.

Radiant tubes were thought the most appropriate method of heating in the assembly department. In this way, rather than heating all areas of a large department, particular workstations where staff activity is concentrated can be targeted. This section is divided into four zones and a total of 22 Powrmatic radiant tubes are mounted at a height of 3.3m.

Diversity of the areas requiring heating at Long & Crawford is illustrated by the contrast between this area and the adjoining section, which houses overhead cranes carrying machinery for factory assembly. A high roof and large opening doors causing high heat loss led to the choice of two floor-standing DFU 750 units on each side of the building. The one closer to the doors is designed to create a pressurised atmosphere to reduce draughts. Three Calecon CE2250 thermal economiser fans optimise efficient use of energy. When warm air rises into the roof space, a thermostatically controlled fan is activated blowing the air down to floor level where it is required for staff comfort.



A PGUH heats the workbay and a direct fired warm air heater is used in the assembly area

In the stores areas and additional work bays, the PGUH range of suspended gas unit heaters are used.

One of the two remaining bays is fitted with a single PGUH 200 special with a mixing box for fresh air and recirculated air. It incorporates a heat exchanger made of stainless steel: for more resilience to withstand the adverse effects of process techniques than may corrode the metal. The third bay's heating is provided by 2×PGUH 140, with a Calecon thermal economiser.

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