FAT vav: what is it?

FAT VAV

What was once the preserve of the USA has caused a minor revolution in the design of vav air conditioning: the fan powered mixing box. As the massive purchasing power of the American-backed Canary project re-writes the manufacturers catalogues, we lay down some design guidance for the installation and control of fat vav.

Below: Fan assisted vav box at Bridge House, a development by Norwich Union in Guildford.

The developing technology of system operation within offices has resulted in a rapid increase of distributed processing equipment. This, in turn, has led to increased heat generation, thus imposing additional loads on cooling systems. Whereas equipment design loads of 10 W/m^2 of office space were once the norm, this has now increased to 40 W/m^2 with the possibility of further increases.

To deal with these loads, designers have been forced to modify the ubiquitous variable air volume (vav) system, (itself a 1980s response to cooling needs) by either increasing the volume of air through the system, operating a secondary chilled water distribution system, or by supplying cooler primary air. However, these modifications can cause problems of their own.

For a start the performance of a vav system depends largely on the turndown performance of the air terminal diffuser (see figure 1). With a well zoned traditional vav system, perimeter diffusers are required to turndown to approximately 40% due to the constant loads afforded by solar, infiltration and conduction gains. As the only variables acting upon terminal units are occupancy rates, lighting and equipment loads, the internal zone units may have to turndown to 25% – way beyond the performance of the diffuser (see figure 2).

Some diffusers perform better, some worse. But as a norm, when a vav diffuser is asked to turn down below 40%, the air pattern will de-stablise, the coanda effect will no longer work and the air will begin to dump. Furthermore the hysteresis effect means that in order to get the air to stick to the ceiling once again you have to increase the air volume to around 60%, with all the attendant problems with draught that this entails.

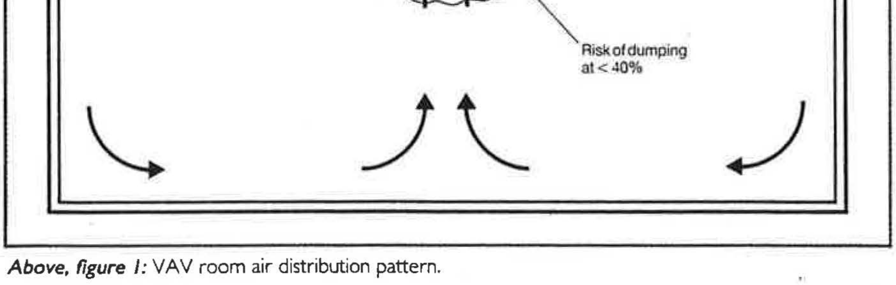
What is required, therefore, is a system that meets these requirements but still gives the advantages of a traditional vav system, ie centralised plant and minimal maintenance at the terminal devices.

Putting a fan into the vav terminal to boost the air flow provides an alternative to conventional throttling terminals. This fan mixes the cooler primary air with recirculation room air (see figure 3). This provides a near constant volume of supply air to the room with variable mixed air temperature to satisfy the cooling load.

Fan assisted terminal vav units (fat vav) are available in either parallel or series flow configurations. The parallel unit uses its fan to boost the air flow at high primary air turn-down ratios. The result of this is still a variable volume system but the variations are reduced.

The series flow unit effectively changes the variable volume constant temperature primary air into constant volume variable temperature secondary air. This is achieved by running the unit fan continuously. Make-up air to balance the variations in primary supply air is drawn into the unit from the ceiling void. A feature of this system is that good consistent mixing can be attained.

Such devices are now widely available,



Above, figure 1: VAV room air distribution pattern.

due in no small part to the mass purchasing programme implemented by the American developers of Canary Wharf.

Like many others, consulting engineer Oscar Faber has been investigating these systems for some time. By superimposing air conditioning designs on a computer-generated 11 000 m^2, three-storey building, and by running an energy simulation program, Oscar Faber was able to make comparative tests on energy consumption between standard and fat vav.

It was found that by using a standard weather tape and by taking into account operational profiles, fan on-times etc, the fat vav design consumed less energy overall than a traditional vav system (see figure 4). This is based upon the traditional vav system having to be supplemented with a secondary chilled water distribution in order to deal with increased cooling loads.

Since the diffuser uses a blended air temperature from the fan assisted box, it is possible to consider the economics of using low temperature air. This can be achieved in several ways: lower chilled water temperatures, the use of thermal storage systems or, in the case of Faber's first fat vav installation at Bridge House in Guildford, the use of a direct expansion system.

Here the main air handling unit has been located on the roof and comprises a dx coil close-coupled to an air cooled condenser. This is a particularly neat solution, as the ahu was completely prefabricated off-site with all controls prewired in the factory. The plant is also smaller and the use of direct expansion coils from refrigerant plant is more efficient in space use than traditional chilled water plant and pumping equipment.

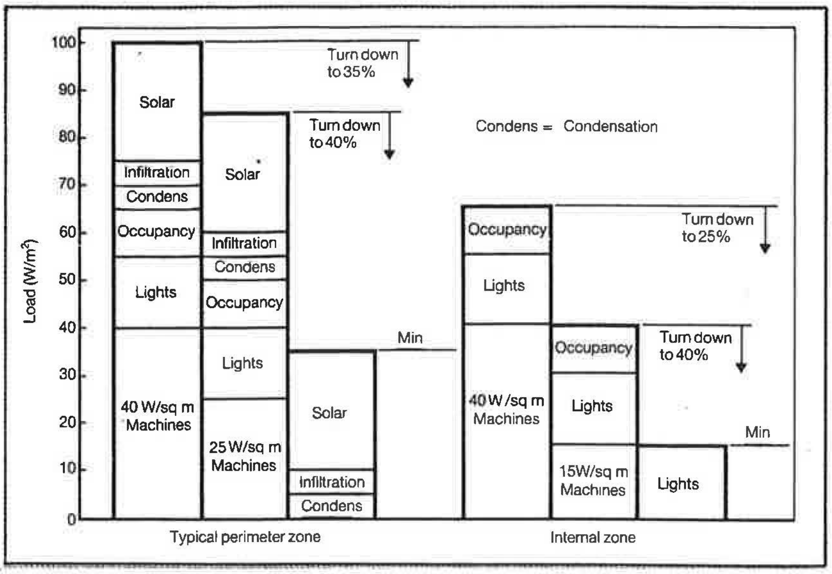
However care has to be taken when putting a dx coil in the main ahu, as there are problems controlling the refrigeration circuit under low load conditions. This problem can be solved by applying a variable speed compressor.

But does fat vav mean that the client will be paying a premium? Fan assisted terminals are considered to be an expensive way out of the problem, after all they can cost up to 2½ times as much as a conventional unit. But when the reduction in ductwork, air handling capacity, air volumes, and coil cross-sectional area is taken into account the savings more than offset the cost of the fans.

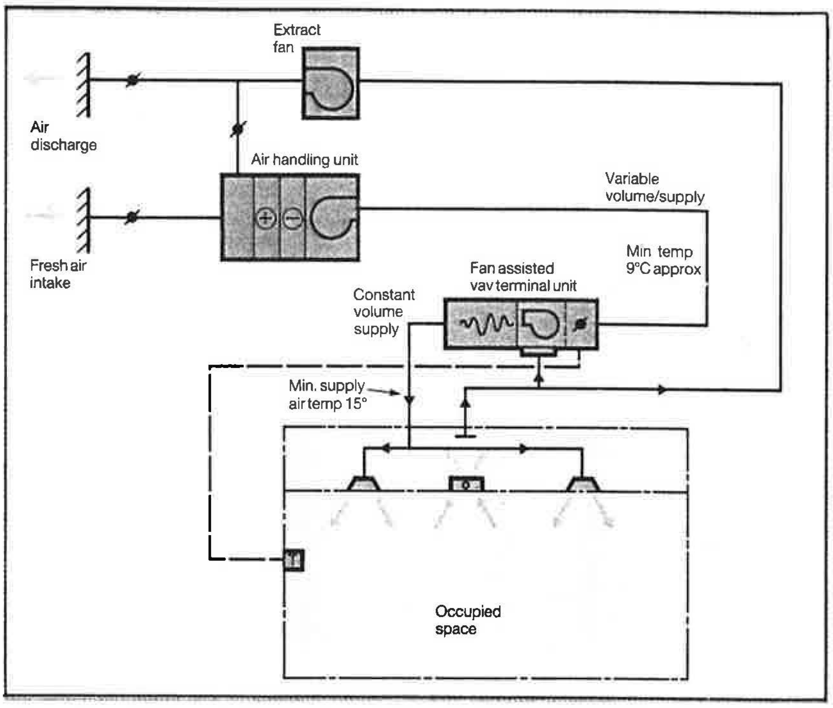
Using low temperature distribution means that a given volume of air will have more cooling potential, therefore far less air is needed. Oscar Faber believes savings over traditional vav can be in the region of 40% .

Maintenance should be little more than for associated terminal controls and in any case the maintenance requirements of a chilled water distribution system would involve additional maintenance to that of fat vav terminal units.

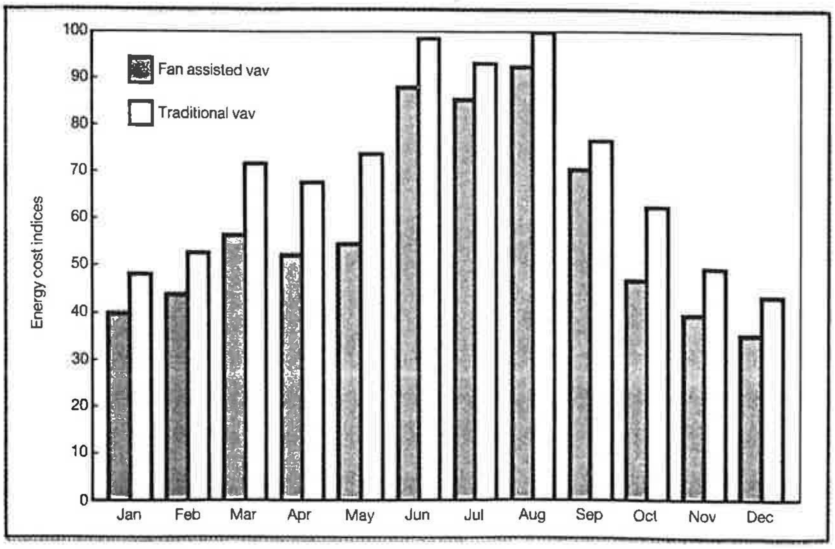
Thanks to Steve Hodkinson of Oscar Faber for assistance in the preparation of this article.



Above, figure 2: Turndown ratios for vav.



Above, figure 3: Schematic diagram of a typical fan assisted vav system.



Above, figure 4: Results of a study by Oscar Faber into traditional versus fat vav.