#3803

A question of control

John Duffin puts the case for the use of individual direct digital controls in fan assisted terminals which enable sophisticated energy management and monitoring capability.

Fan assisted terminals (fat) might be considered simply as conventional vav terminals with fans installed. The vav dampers can be controlled using conventional pneumatic or electric/electronic controllers and the fat fans can all be switched off when the associated main plant is switched off.

Is there any need to consider the control strategy any further? The answer is possibly not. The strategy described above would provide a solution and a basic level of comfort would be provided.

However, the reason for considering other options is, quite simply, that it may be economically viable to provide greatly enhanced control facilities that would be of benefit to the design engineers, the commissioning engineers, the installation contractors, the owner and the tenants. Just as vav is not a solution to all air conditioning problems, fat systems are most suited to particular applications. Therefore to properly appreciate the benefits that can be obtained, it is important to consider the type of buildings in which fat systems will be installed.

In general, fat systems will be found in the larger office development where, due to the nature of the building, a building management system (bms) controlling the shell/core plant will have been installed. A high degree of flexibility will be needed from the air conditioning system because it is likely that initial and long-term tenant requirements will be quite diverse.

Incorrectly managed, such a development has the potential to consume large amounts of energy and have commensurately large running costs which cannot be accurately apportioned. Consequently there is a need for a control system that will:

☐ ensure minimum energy wastage and provide the smallest possible energy costs for the specific type of building;
☐ provide monitoring and control of environments, on a zone by zone basis, in order to satisfy user requirements and apportion local and central plant running costs;
☐ be flexible in use so that premature control system redundancy is avoided should user requirements change.

The use of a direct digital control (ddc) terminal unit controller dedicated to each fat will provide greater installation and operational flexibility and, when fully interfaced with the shell/core bms, would allow:

☐ tenant space conditions to be accurately monitored and controlled;
☐ a reduction in tenant complaint calls as corrective actions can be taken prior to the tenant realising that the local environmental conditions are drifting away from setpoint;
☐ tenant after-hours energy usage to be more easily monitored;
☐ flexible local strategies to be employed;
☐ building-wide energy management to be implemented allowing the optimisation of energy use in the primary mechanical equipment while ensuring that tenant comfort is maintained;
☐ spare capacity in the fat controller can be used for control and monitoring where previously this could not be economically justified;
☐ fat ddc controllers to be easily added, moved or deleted from the system without bms input/output capacity.

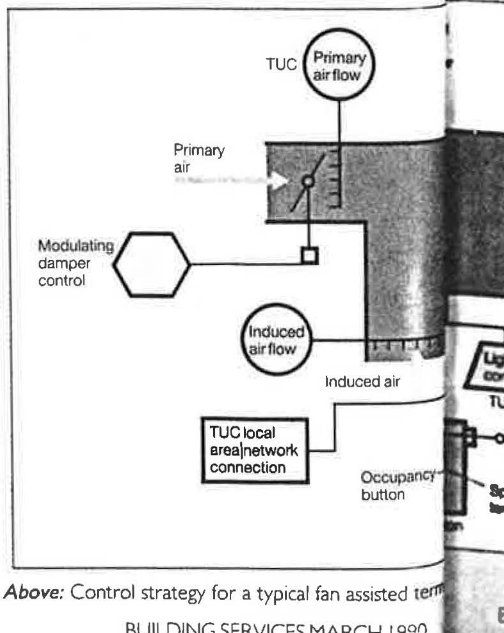
Using ddc controllers with fat units will result in more accurate control of conditions within a tenanted space than is possible with pneumatic or electric/electronic controllers. This is possible due to the increased accuracy of sensors, the use of proportional integral derivative (pid) algorithms (as opposed to the simple proportional or binary algorithms typically employed in conventional systems) coupled with the fast response of the ddc sensors.

A reduction in tenant complaints can be achieved using the ability of the fat ddc controllers to interface with the bms and automatically generate alarms should out-of-limits conditions occur. Often the operator will be able to diagnose faults and take action from the bms central station because access will be available to all bms and fat ddc controller parameters.

The often difficult problem of monitoring after-hours air conditioning can be greatly simplified by using this type of system since each terminal can be treated as a single zone, independent of other zones in a way that would not have been economic with conventional systems. Consequently, a tenant ean use his space without needing all areas served by the ahu to be operational.

The control of time extension can be accomplished in a number of ways. A tenant could contact the building operator and required schedule changes could be made manually, although this method tends to be unreliable in practice. Local occupancy buttons or motion detectors could be used to provide a preset overrun period. While better than the manual method, this requires a button or motion dectector in each occupied area, several of which may be served from one fat box.

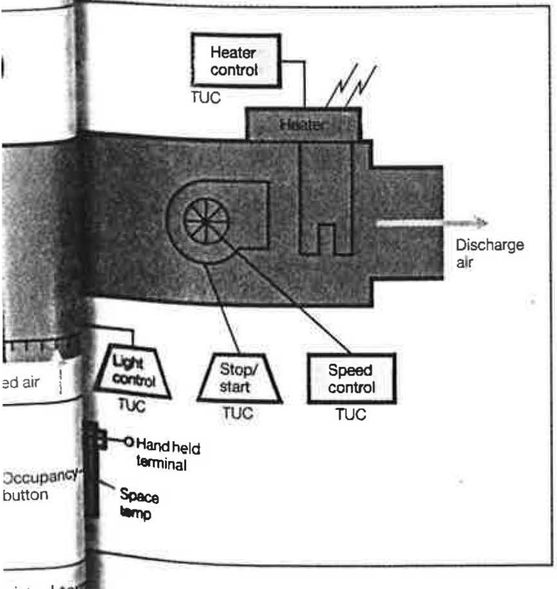
The optimum method involves the use of a dial-up modem to operate the local



Above: Control strategy for a typical fan assisted ter terminal unit. This can be done using a voice synthesiser and an interactive question and answer routine with the tenant sending instructions through the telephone keypad.

Once fat ddc controllers have been integrated into a bms, the opportunities for implementing building-wide energy management strategies appear. Since all building environmental conditions are being monitored, the bms can use closed-loop algorithms to schedule the operation of plant. Typically:

□ main ahu supply temperatures and static pressures can be automatically reset if tenant environmental conditions are being maintained without the fat dampers being fully open;
□ lphw temperatures can be reset allowing the use of boilers to be minimised by using internal heat gains, to warm spaces;
□ chilled water supply temperatures can be reset, or chillers can be duty-cycled during the day and shut down early if space conditions can be maintained within limits;
□ ahus can be duty-cycled while leaving local fans running if space conditions permit;
□ maximum demand control strategies can be used, disabling fat electric heaters during peak demands;
□ night setback and condensation/frost protection strategies can be used, operating only in those areas which the bms reports as actually needing protection.



These features are additional to normal bms energy management functions such as boiler sequencing, chiller/cooling tower optimisation and electrical maximum demand control.

One of the greatest advantages of using a fat ddc controller system, although one that is not immediately apparent, is the way that spare capacity within the controller can be used to control and monitor functions which could not economically dealt with in other ways. Lighting control is an example of this sort of function. Normal and out-of-hours lighting for each zone could be time scheduled in much the same way as the fats. It is worth noting that when using this arrangement it would not be necessary to provide switches, conduits and wiring for the lighting controls and, consequently, capital cost savings can be made by the use of the fat spare capacity *in lieu* of the more traditional wall-mounted light switches.

Selection

To realise these benefits it is essential that a proper system selection is made. The following points should be borne in mind.

In a typical all-electric fat ddc system, the ddc controller attached to the fat unit senses space temperatures and both primary and total air flow rates while controlling the vav damper and the heater. The sensing, actuating and controller functions are areas where particular attention must be paid to ensure that the fat control system will operate correctly.

The ddc controller should be installed in the ceiling void, usually on the terminal itself. It must be physically robust and installed so as to minimise the possiblity of damage during installation and commissioning.

Particular attention must be paid to ensuring that electrical interference, especially from lighting, lifts and the fat fans, does not affect operation of the controllers. Controllers must also be protected from voltage fluctuations within the building and must be configured to leave equipment in a safe condition in the event of power failure and to restart equipment safely on restoration of power. Conversely, care should be taken to ensure that the fat fan motor speed-controllers do not introduce harmonics into the electrical distribution system.

It is obviously important that the air flow rates and space temperatures are accurately reported. Good quality sensors correctly sited in representative positions within each zone are recommended, as are multi-point air flow sensing grids with differential pressure sensor/transducers. Past experience demonstrates that inaccurate flow measurement can seriously affect tenant comfort, so unless the fat ddc controller is a proven configuration, it is sensible to have calibration checks made at an independent laboratory.

The final control elements should be specified to ensure that the controller actions are accurately translated into damper/valve movements. The bms can subsequently be used to report on the operational status of the system by monitoring deviations from control setpoints.

The operator interface also needs careful consideration. Once installed and commissioned, the ddc controllers will be difficult to access in the tenant areas so provision needs to be made for operator access data and control functions. Ideally this will be possible through the use of a hand-held terminal connected via a plug in the wall-mounted sensor enclosure. If not, it may be necessary to use a portable pc at a remote location, with consideration given to the siting of suitable access points.

The integration of the ddc controllers into the bms needs careful specification to ensure that a consistent user interface is provided, so that information from both the main bms and the fat ddc system is in the same format.

At present, many bms and fat ddc systems made by different manufacturers are incompatible. An incorrect or uncoordinated choice at an early stage can cause the specifier to be locked in to one supplier, removing the competitive element; or worse still, can result in the installation of bms/fat ddc controller systems with an incomplete or non-existant interface.

As a minimum, the ddc controller should be capable of providing pid control space temperature. It must also be possible for the controller to hold, in a suitably protected form, time schedules for each zone.

It is essential that the bms can access the ddc controllers, both singly and globally, to upload/download new time schedules and synchronise the main bms and individual ddc controller clocks. The bms must also be capable of holding a backup of these schedules so that they can be automatically uploaded in case of controller failure. These points are particularly important when thousands of ddc controllers can be addressed by a single bms.

Procurement

The relevance of procurement may not be immediately obvious. However, without a clear procurement policy stated in the specification/tender documents, the purchaser could easily fail to realise his technical and financial objectives.

Owing to the uncertainties that often occur during construction prior to the finalising of tenant requirements, it is beneficial to employ a unit pricing strategy in the tender documents. This will protect the purchaser against price fluctuations later in the project and allow accurate budget forecasts.

It is also wise to obtain pricing for those unpredictable activities that will inevitably occur, such as moving of sensors. It is also advisable to build in allowances for calibration checks, to be made by the installer, during the warranty period.

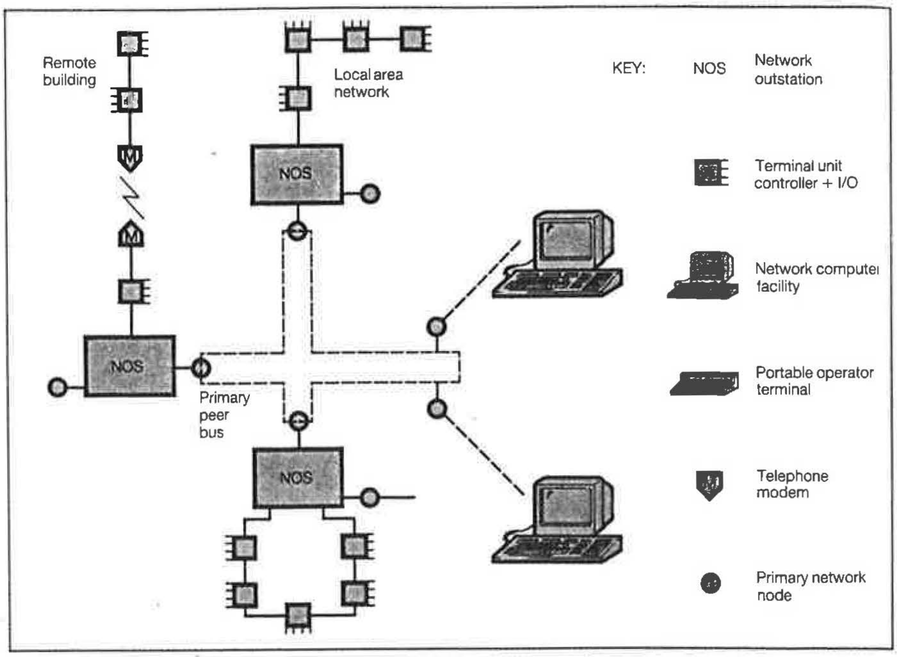
Installation

There are a number of areas where the use of ddc controllers can produce benefits during the installation. First, the controller, sensors, valves and other interface devices can be delivered to the fat manufacturer to be assembled and tested off site. This reduces on-site work to simple wiring, and the initial commissioning to communication network checks. This not only saves time but, crucially, improves quality and protects the installation programme by deskilling the onsite task.

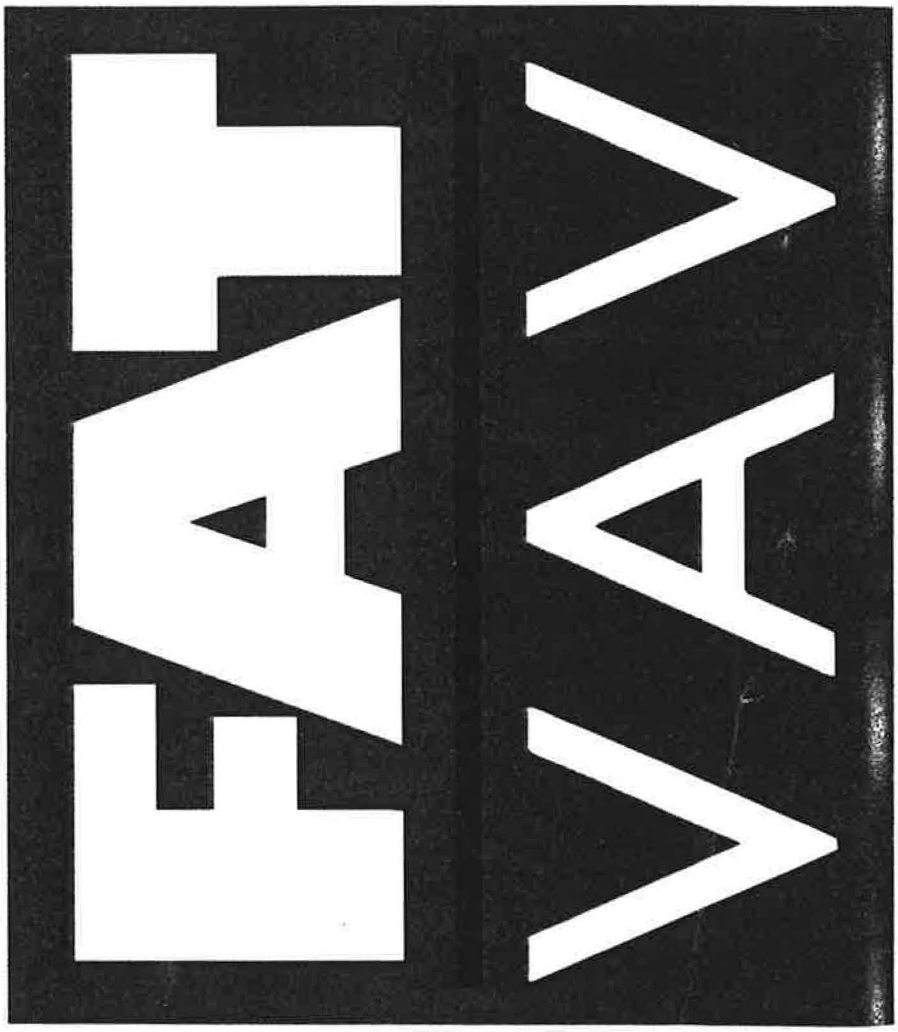
Secondly, the bms contractor can balance all of the air systems through the bms using the airflow sensors built into the fat box. This includes setting maximum and minimum air flows for each fat primary air damper and the air flow for its fan using the in-built fan speed controller. This eliminates the need for on-floor checking and ensures that any air balancing work does not compete with other on-floor activities. Furthermore, this approach allows for the air conditioning in any area to be re-commissioned through the bms at any time, without disruption to occupied areas.

To cope with unforeseen demands, oversize fat units could fitted and reconfigured for the current tenant demands. This would eliminate the need to move terminals if tenant requirements change.

It is important, for all of these operations, that the responsibilities of the various contractors are clearly defined. A number of contractors will be involved and it is essential that their activities are correctly co-ordinated and supervised. The interface between contractors should also be clearly defined in the specification and should, where necessary, include the definition of physical interfaces, such as terminal strips, between the various contractors' areas of responsibility. A mistake in installation of one terminal unit could easily be repeated on thousands of others and mightnot be discovered until final commissioning.



Above: Control through an integrated building management system.



Conclusions

Fat vav systems have been in use in North America for four to five years and, when applied correctly, have been found to bring significant benefit to all stages of the design, installation and operation of many building projects. However, despite the many advantages that can be obtained, there are, from the designer's point of view, many pitfalls for the unwary. To obtain the full benefit from this approach the installation of a fat ddc control system should be considered at the earliest stages of the project, and care must be taken to ensure that it is correctly designed, specified and customised to meet the needs of the specific project.

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