MASTERCLASS - AIR CONDITIONING TECHNOLOGY

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Last month (Part 56) we covered Liquid Pressure Amplification as applied to DX Systems. This month we have decided to move into the Close Control arena in which we plan an in-depth study of the market, equipment and applications.

"CLOSE CONTROL" AIR CONDITIONING

A general introduction to "close control" or precision air conditioning – highlighting the differences with comfort air conditioning. Specific computer room applications are discussed this month. Next month we consider telecommunications installations and in the final article of the series we consider industrial applications and go into more detail about the various control and monitoring systems.

Introduction

In some ways, the term "close control air conditioning" is a misnomer. Whilst there certainly are applications where precise control of temperature and humidity as well as high standards of air filtration are necessary, many applications involve quite a wide temperature envelope, and even wider humidity specification, but are still best served by what has become known as "close control" equipment.
Other terms used are "precision air conditioning" and "high performance air conditioning" So how does equipment designed for these applications differ from "comfort" air conditioning?
Comfort air conditioning is applied to occupied areas such as restaurants, domestic environments, shops, and offices, and motor vehicles. It is generally accepted in the workplace that comfort air conditioning has a positive influence on productivity, health, and attendance.

Precision air conditioning is defined as "the simultaneous control of temperature, humidity, air motion and cleanliness in a specified area, continuously and accurately"
Note that the priority for precision air conditioning is not necessarily the comfort of the occupants; it is the reliable and efficient operation of equipment that matters. In fact some machine rooms are not even occupied for most of the time.

Temperature

Early computer components were very sensitive to both excessive temperatures and temperature fluctuations, and generated very large quantities of heat in relation to their computing power. In the seventies and eighties, large "data centres" housing mainframe computers and associated memory banks required many tons (to use American parlance) of close control air conditioning.

At the beginning of the nineties there was increased use of networked personal computers and small file servers. Electronics became increasingly less sensitive to higher temperatures, with the use of "military specification" components. However the heat density increased significantly. A heat density of 750 Watts / m^2 was previously considered the maximum, but consideration is now being given to schemes with 2400 Watts Watts / m^2.

So why does the requirement for computer cooling continue to increase? One answer is the explosive growth of the Internet. This involves large centralised computer and communications centres that are accessed by the various service providers.

Reliability of such systems – indeed any computer system today – is paramount. Even if electronics can safely operate at temperatures as high as 50 deg. C. reliability is increased if the operating environment is controlled between 22 and 24 deg. C. Also because of the enormous investment in software, the mainframe computer is by no means dead. Large data centres continue to be built and refurbished, and most organisations today have at the very least a secure combined communications and computer room.

Relative Humidity

What about humidity? Early computers with their punched cards and tape were adversely affected by humidity variations. High humidity could result in water condensation on the printed circuit boards or other sensitive components. Low humidity conditions could cause uncontrolled electrostatic discharges – at voltages that would destroy solid state devices and microcircuits. The relative humidity for computers has therefore to be controlled usually between 45% and 55% RH.

This brings us to one of the most important features of close control air conditioning. The heat load has a very high sensible heat ratio. By this is meant the ratio of sensible load ("Dry heat") to total load ("dry heat plus latent heat associated with moisture vapour in the air"). It may be as high as 0.99. In comparison for comfort air conditioning the ratio may be in the region of 0.65, because of contributions to the latent load coming from people and fresh air.

So the main cooling coil in a close control air conditioner needs to be very different from that in a comfort unit. It needs to be designed with a high sensible heat factor – otherwise excessive moisture will be taken out of the air ("latent removal") that will have to be replaced by humidification if the humidity requirement is to be fulfilled.
This is what can happen if a comfort unit is used in a small computer room. The relative humidity is brought down to too low a level. If a humidifier is installed to compensate, the running cost of this can be higher than that of the air conditioner itself!

Air Filtration

Computer components and microcircuits are very sensitive to dust particles and air filtration standards need to be higher than that required for comfort air conditioning (typically EU4 filtration compared with EU2 for comfort). Close control air conditioning systems also find application in clean room installations, and it is not at all unusual for an electronics environment to be significantly cleaner (in terms of dust particles per cubic metre) than a hospital operating theatre!

Air circulation

In order to avoid excessive temperature variations within a controlled space – as well as preventing "hot spots" within the computer equipment itself, air recirculation has to be maintained at an appropriately high level. Electronic cabinets themselves have built-in air circulation; the temperature of the air drawn in by such systems is itself critical. A comfort system with a heat density of 50 Watts / m^2 can tolerate a relatively wide temperature, whereas a critical area may have over 1000 Watts / m^2 with a limited temperature variation. This may correspond to an air circulation rate ten times greater for the critical system than for the comfort system.

The classical ducted distribution via grilles may be inadequate – the use of a complete floor or wall for air distribution may be necessary. Advantage is very often taken of the raised floor in a computer room; the space between the raise floor and the sub-floor is used as an air supply

plenum. The air conditioning units themselves are situated within the room or in an adjacent plant “corridor” so that the use of ducts is minimised or eliminated.
Year round operation

If a problem occurs with a comfort air conditioning system, it may be possible to open the windows or at the worst not use the facility for a brief period. A real problem is only likely to occur in any case during summer months. Such a course of action is not possible with a critical installation. Even a few moments off line for a computer can cost thousands of pounds, and because of the high internal heat loads involved, the external heat gains or losses may be relatively irrelevant. A “close control” installation has to operate continuously throughout the year without interruption.

Energy conservation

This fact has important consequences in terms of energy use, reliability and maintenance. Even before the current concerns with energy conservation, the fact that the computer air conditioning system could account for 30% of the electricity bill for a data centre has meant that designing systems for minimum energy consumption has always been a priority.

Reliability

Electric motors, compressors, valves, humidifiers – all these components are essential parts of a precision air conditioning system and none of them are 100% reliable. The only way to meet the reliability demands is to ensure that if any of these items do fail, the system continues to meet the environmental specification requirements. Units may be designed with duplicate refrigeration circuits, so that if for example there is a problem with an expansion valve, the other circuit can at least handle a part of the heat load. Run and standby systems are common in smaller applications, whereas the concept of “N+1” redundancy is employed on larger installations.

Practically all close control installations use packaged unitary plant, which is factory tested before despatch to the site. With Eurovent certified performance, the end user can have confidence that the duty will be met.

Maintenance

Regular maintenance is an essential feature of precision air conditioning installations; however the problem is that one must continue to operate the system during servicing, or alternatively select a shut down time when minimum disruption occurs. Christmas morning at 2 a.m. may seem to be a possibility, but how much are you going to have to pay a service engineer to get out of bed at that time, and the Internet providers will not be happy if they lose their system.

Direct expansion air-cooled packaged units present numerous advantages, as one unit or circuit can be switched off for maintenance without disrupting the rest of the installation. Compare this with a central chiller feeding a number of close control air handling units. Any work on the chiller can affect a large part of the installation, unless run and standby chillers are provided – one might argue at an unnecessary expense.

Controls and Monitoring

Microprocessor controls are used in the majority of precision air conditioning units. Apart from providing complete flexibility in control algorithm through software, the communications facilities that are available make it possible to provide local status and alarm information at the unit itself or remotely on a dedicated monitoring system or Building Energy management System. Facilities exist for a service engineer to be sent a text massage on his mobile telephone giving brief details of an equipment fault. Using his Laptop PC, he can make adjustments to the temperature and humidity set-points, or switch on a standby unit so that the critical installation continues to run whilst he is on his way to the site.

COMPUTER ROOMS

Specifically what air conditioning equipment is used for computer rooms? It is usually in-room packaged plant, although occasionally for security reasons the plant corridor approach is taken. If no one is allowed into the computer room itself, air may even be ducted to and from the critical space,

Let us review the various heat rejection methods:

Air-cooled systems usually employ remotely mounted air-cooled condensers. Because of the year-round operating requirement, refrigerant head pressure control is essential. As the temperature falls, the condenser fan speed may be reduced so as to maintain a constant condensing pressure. Alternatively “liquid back up” control may be used in which the refrigerant flow through the condenser coil is partially by-passed.

Refrigeration compressors are either scroll or semi-hermetic – the latter offering a very high COP on larger systems (20kW unit cooling capacity and above). A typical system will have two individual refrigeration circuits feeding a common large surface area evaporator coil. Optional four step control provides significant energy savings in which each semi-hermetic compressor is fitted with cylinder unloaders. With the compressor running in the unloaded state one takes advantage of what effectively is an oversized evaporator and condenser. The effect is that with 50% of the electrical energy input, one obtains 75% of the cooling capacity. In practice most computer rooms operate at less than their design heat load, and so the four-step approach is very attractive for larger systems.

Most smaller systems use scroll compressors either mounted inside the room unit with a remote air-cooled condenser, or mounted outside in a condensing unit. The operating environment of the compressor is much more conducive to high reliability if it is installed indoors!
The main disadvantage of air-cooled systems is the restriction on distance between the indoor evaporator unit and the external condenser. (between 20 and 30 metres although semi-hermetic compressors can tolerate 100 metres) Also the suction and discharge lines have to be in refrigerant grade copper tube and require specialist installation. Also air-cooled condensers take up what may be valuable space outside.

Water cooled systems using a closed circuit cooling tower give more flexibility in terms of pipe runs Reliability is less as the system is dependent on water circulation pumps (usually run and standby – although auto-changeover mechanism have been known to fail!). Each indoor direct expansion unit incorporates water cooled condensers (either shell and tube or plate) and the condensing temperature is usually in the region of 40 deg. C using head pressure control valves. The energy consumption of the system throughout the year can be less than an air-cooled system, which in summer months will have a condensing temperature of over 45 deg. C.

In countries like the UK where occasionally there are temperatures below freezing point, glycol has to be added to the cooling water. In these circumstances Dry Coolers may be employed for the heat rejection to atmosphere. A straight glycol-cooled system has a great disadvantage. Because there are two stages of heat exchange – the first between the refrigerant and the glycol solution in the condenser, and the second between the glycol solution and the air in the Dry Cooler, the condensing temperature in summer can reach temperatures as high as 55 deg C. As a result the energy consumption is much higher than with a water cooled system.

However there is an option on a glycol-cooled system that can present significant energy savings, even compared with an air-cooled system. This is known as glycol free cooling. A supplementary chilled water coil is built into the unit, and this has the same cooling capacity as the direct expansion coil, when the entry glycol solution temperature is 7 deg. C. This corresponds to an ambient temperature seen by the Dry Cooler of around 2 deg. C. So when the outside ambient temperature is less than 2 deg. C. the supplementary coil handles all the cooling load and compressor operation is not required.

Some versions of this system known as Glycool permit the coil to pre-cool the air before it passes over the evaporator coil – thus reducing compressor run time at ambient temperatures above 2 deg. C. up to a maximum of 18 deg. C.

Energy analysis computer programs calculate the consumption for different weather data, and a recommendation can be made for the most energy efficient system in a given city.

Chilled water systems are still employed for close control applications in spite of their disadvantages. Special “free cooling” chillers are available to take advantage of low ambient temperatures and their use does reduce the running cost of a chilled water system.
The one main advantage of chilled water units is that the room units do not incorporate refrigeration compressors, with their associated noise and need for service access. “Low noise” versions of chilled water units are particularly useful for areas likely to be occupied by data processing staff.

Computer room units – being designed to be normally located in the computer room space, incorporate air circulation fans that can be adjusted in situ to match the static pressure generated either by the false floor or by ducts and associated grilles. With the high air recirculation rates required, fan selection is critical.

Belt-driven fans with fixed speed motors and adjustable pulleys are widely used. Variable speed direct drive fans do not offer the energy savings claimed for them unless invertor drives are used. Forward curved centrifugal fans deal adequately with the pressure drops encountered in most computer rooms, but backward curved radial “plug” fans with their high external static capability and low noise options are becoming increasingly popular.

Dehumidification is achieved in computer room units by cooling the air below its dewpoint as it passes over the coil and then heating it to its desired temperature – using either electrical re-heat elements or hot water coils. Hot gas re-heat may be employed on direct expansion systems and is more energy efficient.

Humidifiers types include Infra Red technology – where the surface tension of a tray of water is broken down by infra red rays releasing water vapour into the air stream that is clean and particle free – but which is not favoured by all users because the water does not actually boil.

Electrode boiler or canister humidifiers comprise a cylinder or “bottle” with two electrodes between which a current is passed resulting in the rapid conversion of the water into steam that is then discharged into the air stream. Ultrasonic humidifiers utilise ultrasonic energy to form a fine mist of water droplets, which evaporate naturally in the airstream thus humidifying the air. Each type of humidifier has its advocates. The ultrasonic humidifier is the most energy efficient, but requires a de-ionised water supply that is expensive to install and maintain. Infrared is extremely rapid in response, and electrode boilers although relatively slow in response, are probably the easiest to maintain.

Air filtration in computer room units is usually EU4 to Eurovent 4/5 standards. The filter units are disposable, and most systems incorporate a means of monitoring the pressure drop across the filter. Once the pressure drop across the air filter has doubled, a signal from this “air clog switch” is fed into the alarm and monitoring system, alerting the service personnel to the need for changing the filters.

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DISCLAIMER:
