MITSUBISHI ELECTRIC DIRECT
AIR CONDITIONING SYSTEMS

Information Guide

Water Cooled VRF Systems

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Issue Six

MITSUBISHI ELECTRIC DIRECT
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Guide to Water Cooled VRF Systems

Information Guide

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today. The guide accompanies a series of seminars, all of which are CPD accredited. The changing face of construction in the 21st Century demands that designers, specifiers and suppliers work as teams to create better buildings - for occupants and the environment. Mitsubishi Electric aims to be a part of this by encouraging employees and customers to work together to increase their knowledge of the latest technology, legislation and markets.

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The cool revolution

If you haven't heard of water-cooled VRF systems, you soon will. This flexible and energy efficient technology is set to sweep through the air conditioning market over the next couple of years, with some of the UK's largest suppliers predicting a doubling of the market in 2006.

Water-cooled VRF (Variable Refrigerant Flow) systems are increasingly popular because of a number of features that make them attractive to today's clients. Recent advances in this technology mean that water-cooled systems now offer heating and cooling solutions, with double heat recovery. They can also be linked to one of the most popular forms of 'green' energy – using ground source applications. Water-cooled systems can also utilise heat from areas such as computer rooms, which would otherwise simply be wasted.

The traditional water-cooled system has mainly been used when air-cooled systems won't fit into a building. For example when the pipe runs for tall buildings would be too long to work effectively, water-cooled VRF is an excellent solution. Some forms of water-cooled VRF don't require any equipment on the exterior of a building and can be an ideal solution where large condensers can't be placed on a roof, due to planning restrictions, or architectural design, for example.

Another advantage of water-cooled systems is that they take up less space than their air-cooled counterparts. The system can be split up to occupy smaller areas around a building, which may otherwise be unusable.

Water-cooled vrf systems can run in a number of operational functions: cooling only, heating only and combined heating and cooling. In summer conditions, all the indoor units provide cooling throughout the building. The units receive water between 30–35°C. This water condenses refrigerant and exits the unit at the slightly higher temperature of 35–40°C. This heated water must then be cooled. Traditional methods are dry air coolers, or cooling towers. Once cooled to around 30°C, the water re-enters the system.

In winter, the system is all in heating mode. Water at around 10-20°C enters the system and is used to evaporate refrigerant. It exits the system at a lower temperature, between 5 and 10°C. This cooled water must be heated back up to 10-20°C, before re-entering the system. The usual method is by using a boiler.

While these applications for water-cooled VRF are perfectly sound, there are even more energy efficient options available. For the UK's temperate climate, water-cooled VRF provides a heating and cooling mode, with different units across the building providing heating or cooling where necessary. This is ideal, for instance, when one side of an office is oriented towards the sun and tends to over-heat, while the other side of the building is in shade. It can also be used to cool computer rooms, while providing warmth to other parts of the building.

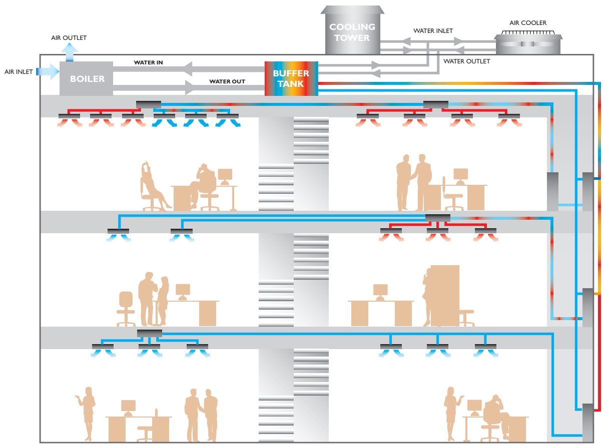
In UK conditions, with all units providing heating or cooling, the units receive the same tempered water, between 20-30°C. This water is used either to condense or evaporate refrigerant, depending on the mode of the unit. Water exiting the units is then heated or cooled back to its original temperature level.

The hot and cold water is fed to a buffer tank, where they mix, providing water at the correct temperature. This element of heat recovery increases the total efficiency of the air conditioning, as no boiler, air cooler or cooling tower is required.

Winter conditions also offer interesting options for water-cooled VRF. This is especially useful in buildings where the computer room air conditioner provides year-round cooling. The water-cooled condenser of the computer room air conditioner provides a source of hot water during the winter period. In winter conditions, this hot water can be mixed with cold water from the water-cooled VRF system in a buffer tank. The capacity of the hot water can be relied on year-round, as the cooling demand from the computers will be steady. This means that the size of boiler can be far smaller, saving on initial capital expenditure, and running costs.

The water-cooled VRF system offers a number of energy efficient cooling and heating solutions. Its growing popularity as a design solution reflects increasing client concerns about energy use. The ability to use otherwise wasted heat from computer rooms, and to minimise use of boilers and water cooling equipment is vital and saves both capital and whole-life building costs.

One of the most exciting developments in water-cooled systems is the ability to link them to ground source applications - an environmentally friendly solution which is set to become increasingly popular as the new Part L of the Building Regulations, and local government sustainability agendas, force developers to think about alternative energy sources. The next feature explains these in more detail.



Traditional water cooled VRF application - UK conditions

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Going underground

Legislation on energy use in buildings, and rising energy costs, are pushing clients and their design teams to look for ever more efficient sources of heating and cooling for buildings. One of the most effective solutions is ground source heat pump technology.

The earth is our largest solar collector and heat storage facility. While ambient temperatures in the UK vary between 0°C and 30°C throughout the year, the temperature just 3m to 4m below the earth's surface remains relatively constant - between 10.5°C and 11.5°C.

Ground source heat pumps utilise this feature, using the energy stored in the ground to provide highly efficient heating and cooling systems. Average coefficient of performance for ground source heat pumps is 6.5.

A ground source heat pump application consists of pipes running into the ground from the building. Water from the building's heating and cooling system flows through the pipes. Depending on the season, this water is either warmed or cooled before returning to the heating/cooling system. For example, in winter, when a water-cooled VRF system is running mainly in heating mode, water from the system is ejected at about 0°C. After running through underground pipes, water returns to the VRF system at around 2.5°C.

There are two main types of piping: closed loop or open loop, with variations on each. One closed loop ground source system consists of a series of vertical U tubes, made from high-density polyethylene pipe. This is placed in a 100mm diameter borehole, with a silica and benonite sand mix. Alternatively, the pipes can run horizontally, in a continuous spiral form, known as a 'slinky'. Closed loops can be buried under buildings and car parks, with no detriment to the operation. Loop capacities range from 6kW to 10,000 kW. It is a low maintenance technology, with a 50 to 75 year life expectancy.

The closed loop system can also be used when the building is near a pond, lake or other non-tidal water source. Water depth of 6m gives a constant temperature of 10.5°C to 11.5°C, as with the ground. The tube is made into coils, and floated on rafts with ballast weights to sink them to the correct depth once they are in position.

For new buildings, where there is limited space, it is possible to use the building piles to house the closed loop. The loops are attached to the piling cage, taken to site and put in place. Cement is poured into the cage, with the loops under pressure to ensure no leaks when the cement sets. This also means that no ground drilling is required to house the closed loop.

Some buildings may have access to an underground water source, or aquifer. If this is the case, an open loop system can be used. A borehole runs under the building, down to the aquifer. Water is pumped up from this source, and travels across a plate heat exchanger into the building's heating/cooling system. After travelling through the building, the water is ejected back into the aquifer. There are regulations outlining how far apart the extraction and rejection tubes have to be placed (approximately 100m).

This is relatively simple, low maintenance technology. Architects and clients are attracted to the ground source renewable energy option, as it's far less obtrusive and more predictable than wind turbines or photovoltaic panels. Key issues are careful planning and design for the ground source tubes, which must be done by specialists. The main costs are in the borehole digging, but these are offset since the technology qualifies under the Enhanced Capital Allowances scheme. The technology is proving increasingly popular, and with a growing market, capital costs will start to fall.

Benefits from the ground up

The advantages of using ground source heat pumps include:

- High COP in both heating and cooling modes
- They are classed as sustainable technologies
- The water loop means heat can be recovered and transferred
- Low CO_2 emissions to meet the Government's new legislation
- No plant outside the building - less obtrusive than wind turbines
- No external noise issues
- Low maintenance
- Design flexibility due to the number of system configurations

Under the surface

Correct siting and drilling of the boreholes is vital to the function of a ground source heat pump system. Mark Glasspool of geothermal energy experts Total Concept Solutions, explains: "A geological survey of the proposed site must be carried out, so that you can establish what kind of conditions you're dealing with."

Glasspool says that different soil types will impact on the heat recovery and dissipation process: "Chalk is excellent, as it is porous. Clay conducts less, but a ground source system can still work well in those conditions." The number of pipes in a closed system can be adjusted according to soil conditions.

The process begins with a test borehole, to confirm findings in the survey. The test runs for around 7 days, with water running through pipes in the test borehole. "We take measurements so that we can ascertain the conductivity of the ground at the site," says Glasspool.

Technology in action

Two recent projects demonstrate the uses of water-cooled VRF on its own, and how it operates when linked to a ground source application.

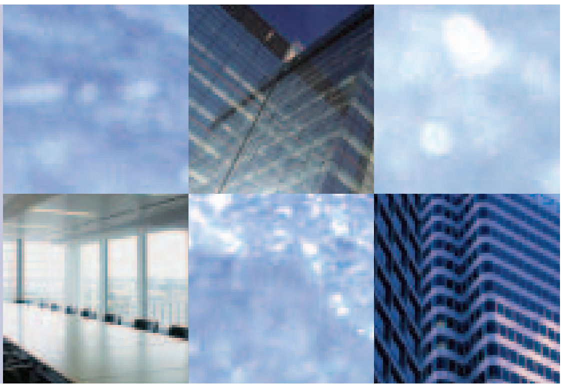
The Nationwide Trust's offices in St Albans, Hertfordshire were in need of retrofitted cooling and better heating. But they are overlooked by residential homes, and face tough planning restrictions, which affected the choice of air conditioning systems. The 1000m^2 building has narrow-plan offices, arranged over three floors.

As with most businesses, use of IT increased, causing greater heat loads. The offices house one of the Nationwide Trust's computer-based call centres. This requires a server room which needs constant cooling. The rest of the office space was largely open plan, with staff becoming very hot in summer. Planning rules prohibited any kind of air conditioning equipment in the car park or on the roof of the building.

The solution to this design challenge is a water-cooled 2-pipe heat recovery VRF system. All the plant for this system is located in the building. All the units are connected to the common water circuit. Excess heat from the server room is recovered to heat the office spaces - making the boiler almost redundant.

A controller keeps the system water temperature between 15°C and 35°C. If the temperature in the water loop begins to rise, dry air coolers in the basement kick in, and the air speed is set to match the heat rejection rate. If the water temperature starts to drop, a standby 30kW boiler activates.

The building now has a system which can heat and cool different parts of the office simultaneously. It also uses heat from the computer servers which would otherwise have been entirely wasted, and hardly ever uses the boiler.



Energy in the pipeline

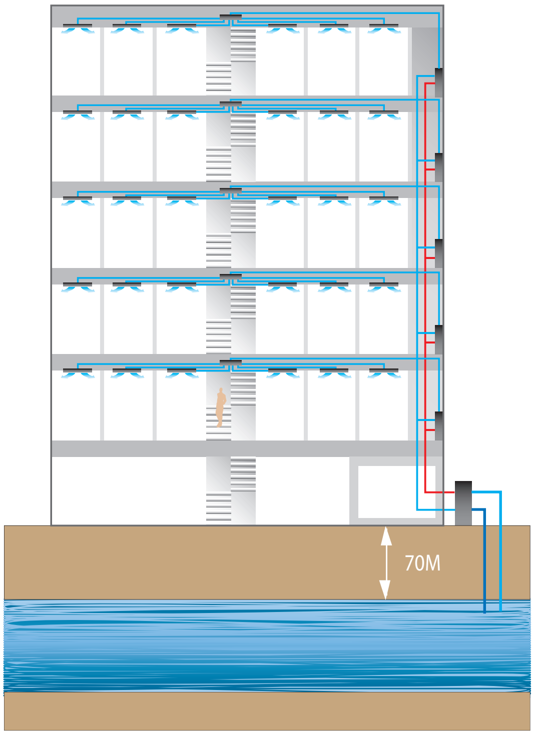
The Zetter Hotel in London's Clerkenwell area also required careful siting of plant. The architects wanted a cooling and heating system which not only allowed for sustainable energy, but also avoided using valuable roof space, that was earmarked for penthouse suites.

Again, the water-cooled VRF solution offered heating and cooling, with plant that could be installed in small spaces. This project was an early adoption of the technology, and used year-2001 units. The seven condensing units in the Zetter Hotel are installed in small service rooms on each floor. These link to floor-standing units concealed in each hotel room.

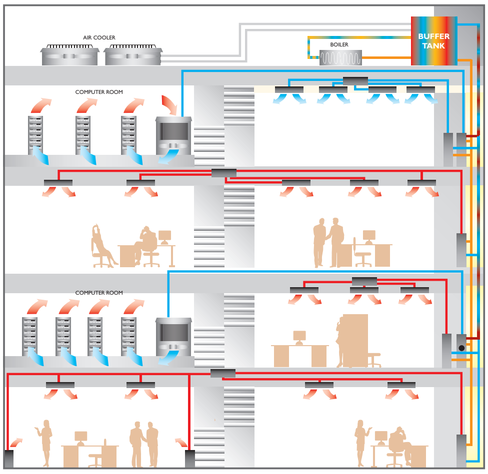
The Zetter Hotel water-cooled VRF system supplies heating and cooling to different parts of the building simultaneously. What is unusual about this project is that the system uses an aquifer which lies below the hotel for heat recovery. This underground lake is around 130m below the hotel, and provides water at a constant 13°C to 14°C. The water is pumped up the borehole, and passed through a plate heat exchanger and metered before being piped to the sewer.

Further heat recovery is possible between the condensing units and the indoor units because some are in cooling mode while others are in heating mode. This double heat recovery provides maximum energy efficiency. Continual monitoring of the system shows that the water-cooled VRF system at Zetters provides a range of COPs between 3.48 to 6, depending on operating conditions. This is an average COP of 4.0, which is excellent performance for units installed four years ago.

These two projects exemplify the latest thinking in air conditioning - make it smart, make it efficient and make it environmentally sound. Technology has continued to develop since these projects, and it is now even more energy efficient. For example, the Zetter Hotel project would now be fitted with new R410A equipment, and the range of COPs would be between 4.5 and 7.5, giving an average of 6.5.



Ground source application - Open loop



Utilising waste heat sources

Further information

If you missed the CPD seminar on **Water Cooled VRF Systems**, you can call your Mitsubishi Electric Regional sales office to arrange an in-house presentation of this information.

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