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Mitsubishi Electric Guide to Chiller Technologies

Information Guide 64

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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.

This guide accompanies a series of seminars, all of which are CPD certified.

Contents

Introduction

Today's building owners and managers face the challenge of providing comfortable, productive space that is also energy efficient. As the drive to reduce energy waste continues with further legislation, building services are being scrutinised to find more ways to optimise performance.

This Mitsubishi Electric Guide focuses on chiller technologies, as these are often at the heart of cooling and heating systems in buildings. The Guide offers some insights into the latest energy-related legislation, and discusses why now may well be a good time to consider replacing older chillers with new equipment that benefits from developments such as inverter drives and compliance with efficiency standards such as ErP.

The drive to energy efficiency

There are a number of established drivers to ensure high energy efficiency in buildings, including:

- **Part L of the Building Regulations**
- **BREEAM**
- **The London Plan**

However, on 1st April 2018 the Minimum Energy Efficiency Standards (MEES) came into place and these put significant emphasis on the energy efficiency of buildings. MEES is linked to the Energy Performance Certificate (EPC) requirement for buildings which is already in place. Since 2008, it has been a legal requirement that an EPC is produced whenever a building is sold or let.

Government has stated that the aim of the new regulations is to:

"tackle the least efficient energy efficient properties in England and Wales. These properties waste energy - not only contributing to the country's greenhouse gas emissions but also an unnecessary cost on the wider economy."

There are two important stages of MEES to bear in mind:

1 from 1 April 2018, landlords of non-domestic private rented properties (including public sector landlords) may not grant a tenancy to new or existing tenants if their property has an EPC rating of band F or G (shown on a valid Energy Performance Certificate for the property).

2 from 1 April 2023, landlords must not continue letting a non-domestic property which is already let if that property has an EPC rating of band F or G.

The drive to energy efficiency

It is predicted that MEES will have a gradual, but noticeable effect on the commercial rented property market. Figures show that around 20% of commercial properties fall into the F or G ratings for EPCs, which amounts to around 200,000 non-domestic buildings.

With these points in mind, 2018 is a good year to consider updating building services equipment. In the case of chillers, there are other factors which make new technologies an attractive and cost-effective option.

For further information on MEES
Please see Mitsubishi Electric CPD Guide 60

F-Gas regulation on refrigerant use

When faced with the requirement to improve building energy efficiency, there are a number of places that a building owner can start. One area which has a significant impact on energy use is the chiller. If a building incorporates this equipment as part of its cooling system, then it's likely to be a large energy user, particularly if is more than five years old.

There are two other important developments which make a chiller update a prudent business decision as they also impact on the comfort of occupants and ease of long-term equipment maintenance.

The first is the F Gas regulation.
This came into force in 2015, and the legislation aims to reduce the equivalent carbon emissions of Hydroflourocarbons (F-Gasses) by 80% before 2030 by means of an annually reducing quota system.

As F Gasses are used in most air conditioning, chillers, heat pumps and refrigeration systems, manufacturers are being forced to find ways to deliver the same capacity and efficiency whilst also reducing the quantity and carbon content of the refrigerant used.

One way in which the chiller industry is leading the HVAC market is by the use of ultra-low carbon refrigerants known as Hydrofluoroolefins (HFO's). HFO fluorinated molecules have a very low environmental impact, while retaining thermodynamic properties very similar to HFCs - guaranteeing high energy performance levels.

These new refrigerants (such as R1234ze) are leading the way as a means of achieving these goals and many chiller manufactures are now able to offer a range of equipment using these new refrigerants.

Another HFO called XP10 is sometimes used for systems normally utilising R134a (GWP of 1430) refrigerant with screw compressors.

XP10 offers similar thermal properties to R134a as it's a blend of R134a (44%) and R1234yf (56%) with a GWP of 573.

For more information on F Gas legislation
Please see Mitsubishi Electric CPD Guide 63

ErP - better performance from today's equipment

As manufacturers, we are being tasked with producing more efficient equipment and with enabling specifiers to compare products easily with regard to efficiency and performance.

The second important development therefore is the Energy related Products (ErP) legislation. The ErP is part of the Ecodesign regulation (EU) 2015/1188. It is a European policy aimed at improving the energy performance of all kinds of products used in businesses and homes. Each product falls into a 'Lot' and the regulations are being introduced in stages. On 1st January 2018, Lot 21 was introduced.

The products included in Lot 21 are:

- **Warm air heaters**
- **Comfort chillers**
- **Air-to-air air conditioners of over 12kW**
- **Water/brine-to-air conditioners**
- **Fan coil units**
- **Air-to-air heat pumps over 12kW**
- **Water/brine-to-air heat pumps**
- **High temperature process chillers**

The main impact of the ErP Lot 21 will be on the way that chiller efficiency is measured. Ratings will be based on higher requirements for seasonal efficiency, and many older existing chillers will not comply. The ErP uses different performance parameters for different types of product to set the Minimum Energy Performance Standards (MEPS).

Product type	Efficiency measure
Air heating products →	Seasonal space heating energy efficiency
Cooling products →	Seasonal space cooling energy efficiency
High temperature process chillers →	Seasonal energy performance ratio

One of the most significant aspects of the ErP is that it requires measurement of the efficiencies to be carried out by manufacturers to agreed national and European standards. These standards are set out in the Official Journal of the European Union (OJEU). For comfort cooling chillers, the key figure that must be supplied by manufacturers is the seasonal space cooling energy efficiency. This is the overall energy efficiency ratio of the comfort chiller for the cooling season.

The benefit to specifiers, installers and users is that when they look at a product which carries an ErP energy label, they will know that the measurement against the MEPS has been carried out in the same way by each manufacturer - making comparison of performance much easier and more robust.

The MEPS that are set by the Directive depend on whether the chiller is air or water-cooled.

Source	Cooling Capacity	Minimum Efficiency 1/1/2018	Minimum Efficiency 1/1/2021
Air cooled	<400kW	149%	161%
Air cooled	≥400kW	161%	179%
Water cooled	<400kW	196%	200%
Water cooled	≥400kW ≤1500kW	227%	252%
Water cooled	≥1500kW	245%	272%

Information from Official Journal of the European Union, EU 2016/2281, Annex II Tables 3 and 4

It is important to understand that these new measurements of efficiency are for compliance for sale in the EU and the UK under the Eco-design directive.

The Non-domestic compliance guidance remains unchanged. Therefore reporting for planning, Part L and SBEM calculations remains unchanged. The ESEER figures and the efficiency data for the chiller from Eurovent will still remain the information source that must be reported for Building Regulations and SBEM calculations.

Chillers and their functions

Air conditioning is acknowledged as a significant energy user in buildings, therefore chillers can make a significant impact on the energy performance and running cost for many buildings.

The latest chiller technologies help to address this by ensuring that they operate to meet the precise cooling demand of the building, conserving energy usage within the building. The main components of water and air cooled chillers are very similar. Each product contains an evaporator, condenser, compressor and expansion valve. The main difference is whether air or water is used to provide the condenser cooling.

Compressor technologies

Scroll

Small to medium sized chillers and heat pumps (approx. <400kW) often utilise scroll compressors. This type of compressor has very few moving parts which reduces noise and vibration, whilst also offering durability and reliability. Typically, multiple fixed speed, on/off scroll compressors will be employed to provide stages of capacity, however, more stringent efficiency requirements are driving the need to utilise variable speed inverter compressors to maximise efficiency during part load conditions.

Screw

For medium and larger capacity requirements (approx. >300kW), screw compressors are favoured due to their compact size and ability to provide a large, continuous flow of refrigerant. Most screw compressors have the ability to vary their capacity by means of a moving slide valve which shortens or lengthens the compression cycle, however, a more efficient way to vary capacity is also to use an inverter. Multiple compressors can be used together to produce very large capacity systems (>2MW) and screw compressors are currently the predominant type of compressor used in large chillers.

Centrifugal

Centrifugal compressors work differently to scroll and screw compressors as they rely on velocity pressure to compress the refrigerant rather than using positive displacement. This approach allows the compressor design to be low weight and very compact.

A niche product within the centrifugal compressor segment is oil-free compressor technology. Oil-free compressors use a series of magnets to manage the position of the drive shaft within the compressor, using innovative and intelligent controls. This technology removes the requirement for bearings and because these compressors have no bearings they don't require oil to be added to the refrigerant circuit, giving an improvement in efficiency. Further improvements can be found due to the reduction in friction and wear.

Inverter technology

Inverters allow the power supplied to a compressor to be modulated resulting in the compressor being able to operate at different rotation speeds. This delivers varying capacity to suit the demands of the system more accurately, which improves efficiency over traditional fixed speed systems, whilst also reducing the number start/stops of the compressor to reduce wear.

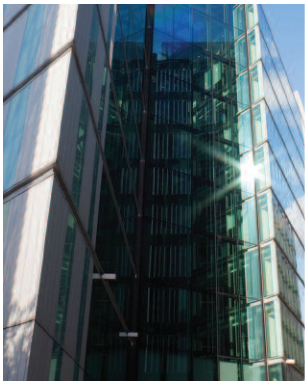
Inverter driven compressors have been extensively used in the DX air conditioning market for many years and as a result of the increased legislation specifically relating to chillers (such as the ErP legislation), and the demand for improved efficiency and reduced energy consumption, inverters are now beginning to be widely used in chillers and heat pumps.

e-series

A modular approach

As modern buildings continue to diversify in their usage, design and function, building services must adapt and provide flexible solutions to meet the increasing demand for heating and cooling.

In the built environment, finding suitable locations to house this heating and cooling plant is becoming increasingly difficult and the requirement for replacement of old equipment in existing buildings also presents a challenge. In countries where space is at a premium and the drive towards increased efficiency is prominent, such as Japan, the solution has been to modularise not only the buildings, but also the building services. Currently in Japan, >90% of all chillers installed are constructed in small modules that bolt together to create larger systems.



This approach has delivered numerous benefits to both installer and end user such as:

- **Reduced delivery times due to mass production and easier stock management**
- **Smaller plant footprints and more flexible positioning options**
- **Staged equipment installation/replacement programmes and easier handling/cranage of small modules**
- **Increased plant efficiency due to smaller increments of capacity and load sharing**
- **Dramatically improved redundancy and resilience due to multiple modules rather than a single large unit**
- **Easier plant maintenance and cheaper parts due to smaller components**
- **Equipment quality improvements due to standardised production**

Clearly these benefits will apply in the UK market and as a result some manufacturers are now able to offer high efficiency modular chiller/heat pumps to meet this growing demand

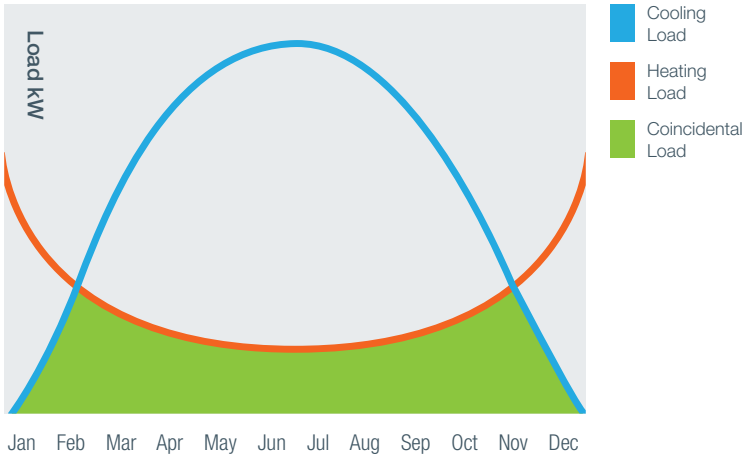
Multi-function heat recovery Chillers

The drive for efficiency and rising fuel costs are leading the search for more innovative ways to conserve fuel and power. A cooling-only chiller, in its simplest form, is extracting heat energy from a building and rejecting this heat energy to the atmosphere in most instances.

However, in many buildings there is a year-round heating requirement, usually in the form of hot water for sanitary use. A chiller that is able to recover the heat energy extracted from areas that need cooling, recover this energy and provide heating where it is needed will be able to realise substantial increases in efficiency and reduce the overall energy consumption for the building.

Due to the fact that in a single building there are areas dedicated to different functions with very variable heat loads, combined with a large percentage of glass surfaces, the simultaneous demand for heating and cooling during the year is becoming increasingly common.

Also, as buildings become more thermally efficient as a result of building fabric improvements, the amount of time during a year that a building requires the cooling plant to be running is increasing. This is typically referred to the 'cooling season.'



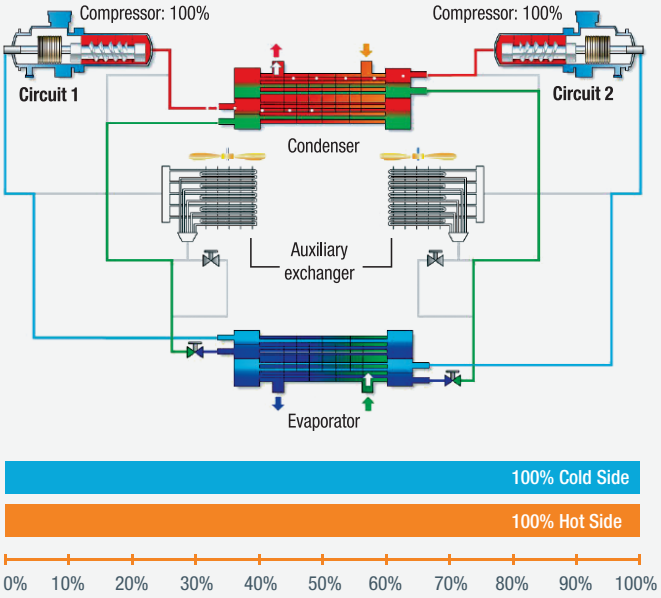
Chillers that are able to provide simultaneous heating and cooling during these periods of coincidental load, provide significant reductions in energy usage and running costs.

An example of a heat recovery Chiller

100% Cold Side / 100% Hot Side

The two circuits operate at maximum power, evaporating in the cold-side exchanger and condensing in the hot-side one.

The source-side heat exchanger (air coil or water exchanger, depending on the type of unit) is not used, which means that in these conditions there is no energy waste.

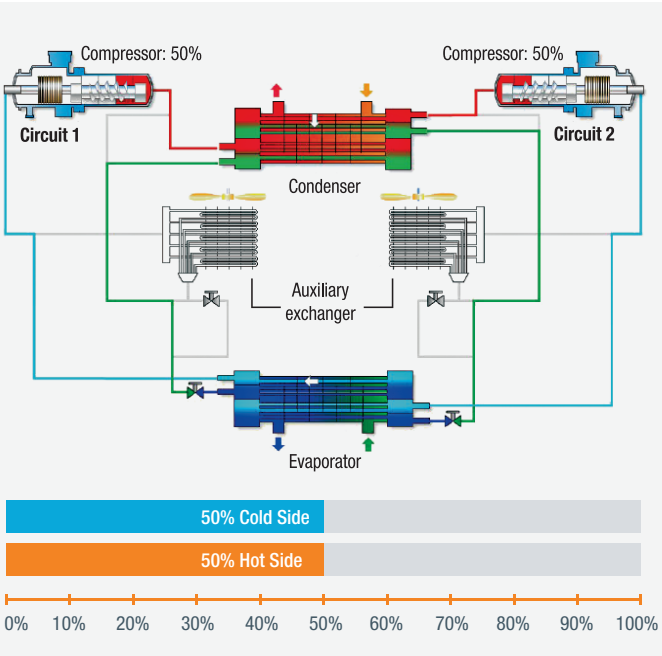


50% Cold Side / 50% Hot Side

In this situation the unit operates like a water-water unit, as all the evaporating and condensing energy is used for the system.

Since the system only requires 50% of the total energy, each circuit operates in partial load conditions.

In this particular state, the exchangers are oversized, thus achieving and even higher efficiency.

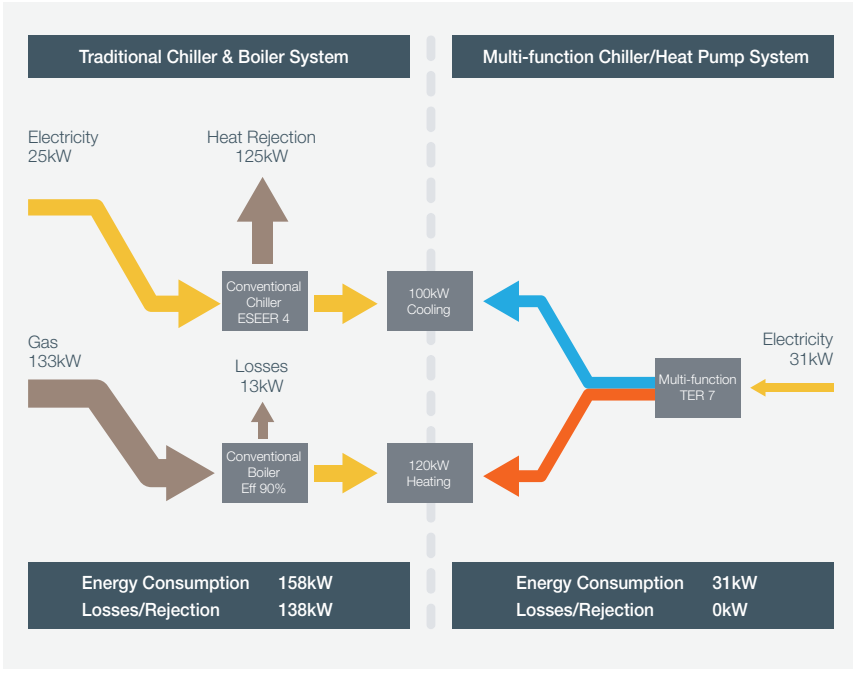


Efficiency calculations

Heat pumps or Chillers commonly have their efficiency described in terms of Energy Efficiency Ratio for cooling [EER] or Coefficient of Performance for heating [COP].

Quite simply this is a ratio of useful energy out to energy consumed. For example a chiller that can produce 7kW of cooling with 1kW of electrical energy has an EER of 7. With a heat recovery chiller, the same ratio of useful energy out compared to energy usage can be applied to provide a Total Energy Ratio (TER).

For example, a chiller that can provide 5kW of Cooling and 5kW of heating simultaneously is offering 10kW of useable energy, but if the energy consumption is just 1kW then we would describe this unit to have a TER of 10.



Time to consider the options

The way we use buildings today is changing, and the energy demands are changing with them. So now is a good time to consider the benefits of upgrading chiller plant.

With legislation pushing buildings towards greater energy efficiency and reducing carbon, and new regulations bringing even more efficient chiller options, such as heat recovery, to the market, specifiers have every reason to take a look at the benefits of a modern chiller for both new construction and retrofit scenarios.

The impact of a chiller on the comfort of occupants should also be considered. With a modern, robust technology in place, building owners can be assured that they are providing a comfortable and healthy environment, as well as saving themselves energy costs in the long-term.

To receive a CPD seminar on Chiller Technologies, you can call your Mitsubishi Electric Regional Sales Office to arrange an in-house presentation of this information.

If you would like to receive invitations to future CPD events, please email **livingenvironmentalsystems@meuk.mee.com**

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