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Mitsubishi Electric Guide to F Gas Regulations and the Future of Refrigerants

Information Guide 78

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Mitsubishi Electric Guide to F Gas Regulations and the Future of Refrigerants

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

The F Gas Regulations were developed by the European Union to phase down the use of fluorinated (F) gases within its member countries. F gases are powerful greenhouse gases, which trap heat in the earth's atmosphere, contributing to global warming and climate change. The aims of the Regulations are to cut the use of F gases and to reduce their release into the atmosphere.

The Regulations particularly focus on the most common type of F gas, HFCs (hydrofluorocarbons). Under the Regulations, each HFC is allocated a global warming potential (GWP) number to reflect its impact on the environment. GWP indicates how much heat is trapped by a mass of the HFC compared to a similar amount of carbon dioxide. The higher the GWP, the greater its potentially damaging impact on the environment.

The F Gas Regulations also introduced other requirements for equipment containing HFCs. These include regular checks, leakage reduction, training and certification of individuals handling HFC-using products.

Although the F Gas Regulations were introduced by the EU in 2006, the original form of the legislation did not accomplish the significant reduction in emissions that was intended. As a result, the EU introduced a new version of the F Gas Regulations in 2014 (517/2014) with the aim of achieving a 79% cut in emissions across the EU by 2030. This is to be carried out through a phase down process that gradually reduces the amount of HFCs permitted onto the market.

EU figures show that the refrigeration and air conditioning sectors are by far the largest users of HFCs. Hence the air conditioning sector has been significantly impacted by F Gas Regulations. Manufacturers have adapted to the rules and developed products that make use of new generations of low-GWP refrigerants - and continue to do so as the phase down of HFCs continues.

The introduction of more environmentally friendly refrigerants into the air conditioning sector is welcome but creates a challenge for installers, specifiers, and designers. Lower-GWP refrigerants have different performance characteristics and there are implications for costs, energy efficiency, installation, and maintenance of those systems.

It is therefore important to understand the F Gas regulations as they impact the UK, and what they mean for developments in refrigerants and the performance of air conditioning equipment in buildings.

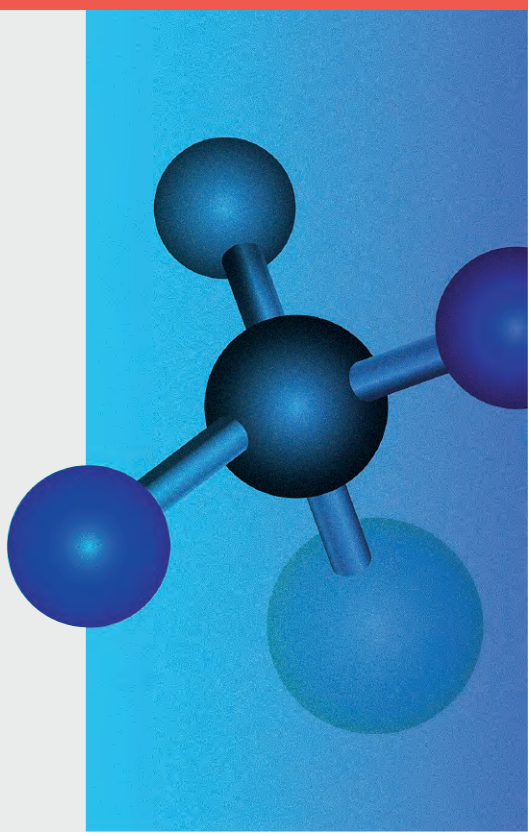
CALCULATING THE **CARBON DIOXIDE EQUIVALENT QUANTITY** OF AN **F GAS**

The UK government offers a method for calculating carbon dioxide equivalent for an F gas[1]. This is an indication of how much a gas contributes to global warming relative to CO_2.

The amount in tonnes of CO_2 equivalent is the mass (in tonnes) of F gas multiplied by the GWP of that gas. For example, the global warming potential of HFC 404A is 3,922.

The tonnes CO_2 equivalent of 10kg of HFC 404A is:

1. Mass in tonnes of F gas multiplied by GWP of F gas
2. = (10/1000) x 3,922
3. = 39.2 tonnes CO_2 equivalent



1. F Gas Regulations in the UK

Because the UK left the European Union, the EU F Gas Regulations have not applied in the UK since January 2021. F Gas regulation is now overseen by DEFRA (the Department for Environment, Food & Rural Affairs). However, the UK continues to use the same schedule as the EU to phase down HFCs and the UK government has stated that it will follow the EU path in future.

The UK objective is therefore a 79% reduction in F gases by 2030 against a baseline of the average volume of HFCs on the market between 2009 and 2012. This rule applies across England, Scotland, and Wales. Northern Ireland continues to follow the EU F Gas Regulations.

F Gas Regulations in the UK will not change the process of phase down, although there are now UK-based IT systems in operation to manage quotas and report on usage. Any company placing F gases, or products that use them, onto the EU market must comply with EU rules.

Phase down - understanding quotas
The phase down process under F Gas, is based on the concept of quotas. The Regulations do not restrict particular HFCs, instead, they focus on reducing the total amount of HFCs on the market in terms of their 'CO_2 equivalent'. This method therefore influences the market to focus on cutting use of the F Gases with the highest global warming potential.

The table below shows the planned phase down of HFCs from 2015 to 2030. The percentages shown here represent the proportion of HFCs allowed onto the market against the reference average (calculated as the average volume on the market between 2009-2012.

For example, between 2021 and 2023 the Regulations limit the total amount of HFCs on the market to 45% of the average amount on the market between 2009-2012.

Time period	Percentage of maximum HFCs on the market
2015	100%
2016 - 2017	93%
2018 - 2020	63%
2021 - 2023	45%
2024 - 2026	31%
2027 - 2029	24%
2030	21%

(Figures from Regulation (EU) 517/2014)

Other requirements under F Gas
The phase down of refrigerants is only one aspect of these regulations. The objective of the requirements is to reduce the likelihood that any HFCs can leak into the atmosphere, impacting the environment. As a result, there is also a focus on checking systems that incorporate HFCs and ensuring that anyone who handles a refrigerant is properly qualified to do so.

The Regulations therefore require:

- Prevention of F gas release (intentional or unintentional)
- Minimisation of leaks and timely repairs when detected
- Regular leak checks and record-keeping. In some cases, leak detection systems are required (e.g., where R32 is present - see below for more details)
- Recovery of F gases for recycling, reclamation, or destruction when equipment is decommissioned or repaired
- Restriction of the sale of equipment to businesses that do not hold relevant qualifications
- Correct product and equipment labelling.

In the UK, handling F gases requires registration on a government-recognised scheme. One example is REFCOM, which is part of the Building Engineering Services Association (BESA). It is vital to check that anyone installing or maintaining air conditioning equipment is correctly certified and registered.

Since the F Gas Regulations control HFCs allowed onto the market, the government must keep track of imports and production. To do this, any company producing or bulk importing HFCs equivalent to 100 tonnes or more of CO_2 must register with the government for an F gas account and apply for a quota. The application must be made annually, and there is a time limit on applications (for example, the window to apply for HFCs quotas in 2022 closed in August 2021).

Once a business has a quota, it may use that to import or produce the HFCs. Alternatively, the business may transfer its quota to another gas producer or authorise an equipment manufacturer or importer to use its quota.

It is against the law to place HFCs on the market if a business does not have the correct amount of quota. Breaking the law can result in a fine or a quota penalty. The Environment Agency can remove 200% of the amount illegally imported from the applicant's quota allowance in the next year and beyond, until the penalty is spent.

2. Current and future F Gas Regulations

It is interesting to note that according to the European Environment Agency (EEA)[2] the phase down process is having the desired effect in reducing use of fluorinated greenhouse gases.

Figures indicate that in 2020 across the EU, the placement of HFCs on the market was 4% below the market limit set by the F Gas Regulations. In fact, all the available quotas were not required to meet available demand from importers and manufacturers. The market is adapting to a low-GWP future.

We are currently eight years from the target year of 2030, with several significant phase-down steps ahead. It is useful to consider what that might signify for allowable GWP levels in HFC refrigerants as we move into the future.

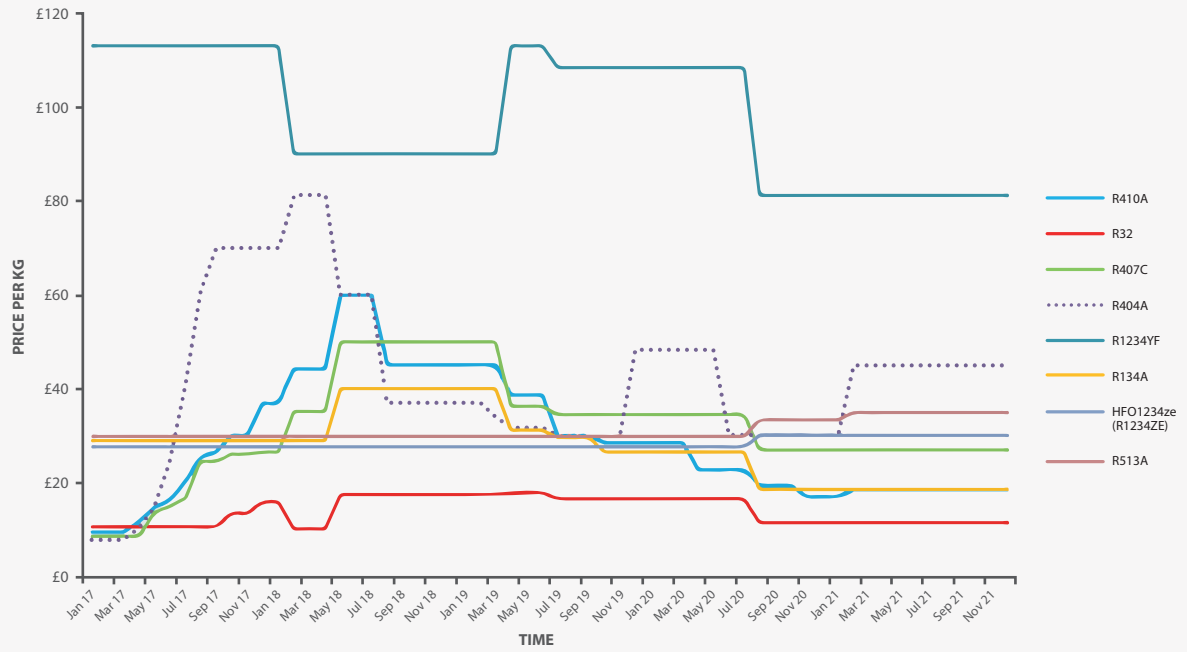
The market estimate of the average GWP level of refrigerants placed on the market in 2013 is around 2300 CO_2-equivalent[7]. With this starting point, the percentage figures can be translated into average CO_2-equivalent consumption figures for each year. The table below shows the potential impact this may have in the coming years:

Time period	Phase-down percentage	Average CO_2-equivalent
2015	100%	2300
2016 - 2017	93%	2139
2018 - 2020	63%	1449
2021 - 2023	45%	1035
2024 - 2026	31%	713
2027 -2029	24%	552
2030	21%	483

One of the reasons that the Regulations have been successful is their impact on refrigerant availability and pricing. At each stage of phase down, the higher-GWP refrigerants have become less readily available on the market, leading to steep or widely variable prices rises in many cases.

This has led designers, installers, and end-users to seek out refrigerants with less volatile pricing, with a view to future-proofing their air conditioning systems from uncertain pricing for maintenance, for example. The graph on the following page shows the fluctuating prices of refrigerants from January 2017 to January 2021. The pattern is that as another phase-down stage approaches, the prices of higher GWP refrigerants tend to rise and fluctuate. The price of lower GWP refrigerants (such as R32 shown as the red line) has remained relatively low and stable over the past few years.

Refrigerant Prices



Source: Average of refrigerant wholesaler market prices

Refrigerants in use today - and tomorrow

As we are currently in the middle of the phase-down route to 2030, the air conditioning market has already seen the impacts of changing refrigerant use. As higher GWP refrigerants were phased out, we have seen increased use of R410A (GWP 2088) and R32 (GWP 675).

Manufacturers are also introducing low and lower GWP to the market in a range of products including VRF and chillers. These refrigerants include hydrofluoro-olefins (HFOs) which are proving increasingly popular with specifiers and end-users. The table highlights some of these new refrigerants:

Refrigerant	GWP	Notes
R1234ze	7	HFO
R1234yf	4	HFO
R513A	631	A blend of R1234yf and R134a
R454b	466	A blend of R1234yf and R32
R32	675	HFC

Future phase downs

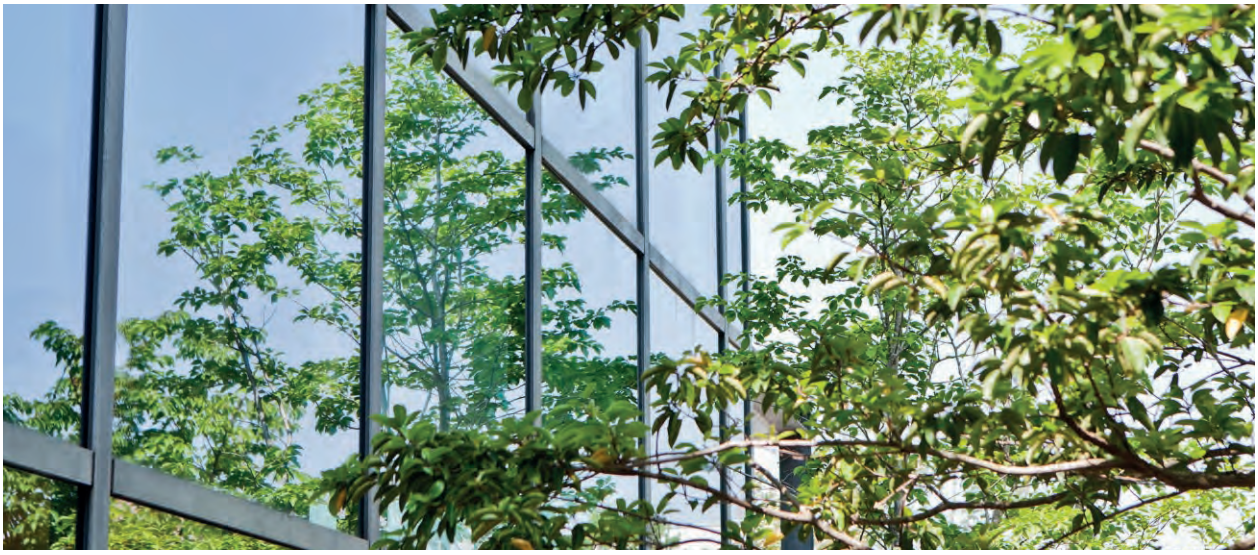
The F Gas Regulations are under continued scrutiny and the market should be aware that changes may be made to the phase down process.

For example, in April 2022, the European Commission set out new proposals to ban the use of HFCs with GWPs of more than 150 in new split system air conditioning equipment and heat pumps (of a rated capacity up to and including 12kW). The proposed new limit would come into force in 2027.

In addition, and with the same deadline, the proposal is to ban HFCs with a GWP of 750 or more in new split systems with capacities above 12kW. Industry reports[3] are that the new proposed phase down percentages will be much steeper and go beyond the current 2030 deadline to 2048.

Time period	Current phase-down percentage	Proposed percentage
2021 - 2023	45%	
2024 - 2026	31%	23.6%
2027 -2029	24%	10.1%
2030	21%	5%
2048		2.38%

On announcing the proposals, the European Commission stated: “The adoption of these regulations would represent a significant step towards limiting global temperature rise in line with the Paris Agreement”. The UK government, which has said it would follow the EU phase down, has said that it is undertaking its own review of the F Gas Regulations and will report on new measures in 2022.



3. Specifying air conditioning for today's buildings

Changes to the regulations on use of HFCs are set against a backdrop of growing demand for occupant health and comfort in buildings. Providing good indoor air quality and high levels of comfort are considered must-have requirements for modern workplaces. And with rising temperatures in the UK, there has never been a greater focus on specifying the right systems for today's buildings.

Designers and contractors must balance several considerations when making their choices, particularly for modern office spaces. As more businesses switch to hybrid working for employees, there are new demands on working space to be increasingly flexible and the provision of services such as cooling, heating and hot water must match those requirements. Landlords who are keen to attract increasingly discerning tenants are also offering facilities such as in-house gymnasiums and showering facilities - requiring a greater provision of readily-available hot water in workplaces.

Added to this is the drive to decarbonise heating and hot water production across all building types. Government has put the use of heat pumps high on the agenda for homes and non-dwellings, so we are increasingly seeing the use of refrigerant-based equipment for these services in place of traditional gas boilers. We are also set to see increased application of heat networks, particularly in cities. Modern ambient heat loops are making the application of water-to-water heat pumps in these loops much more achievable – lowering the carbon footprint of several buildings at once.

There is also a growing interest in the embodied carbon of buildings, and the equipment in them. A proposed new Part Z of the Building Regulations which will set requirements for embodied carbon is being explored in 2022 and government is supportive of this move. This will affect building services equipment which can represent a significant proportion of embodied carbon in a commercial building, which includes the refrigerants in cooling systems.

CIBSE has introduced **TM65: Embodied Carbon in building services a methodology**[4] which provides an approach to calculating the embodied carbon of building services. It is important to note that the type and volume of refrigerant have the most significant impact on the embodied carbon of an HVAC system.

At the same time, other regulations are placing greater emphasis on energy efficiency and lower carbon in our buildings. For example, the new Part L of the Building Regulations (2021) requires that new non-dwellings achieve a 27% cut in carbon emissions against the 2016 Part L.

There are also a growing number of local requirements for major projects to demonstrate long-term energy efficiency. For instance, the London Plan requires major new projects to submit data on energy use for five years after completion. Commercial landlords also face new requirements for Minimum Energy Efficiency Standards (MEES). The minimum EPC rating of E used to apply to new tenancies only, but from 2023 it will apply to existing leases. And from 2027 the government is set to raise the required minimum EPC to C, and from 2030 that will rise to a minimum of B.

In addition, the UK government is also exploring the launch of a new scheme that will rate commercial and industrial buildings (over 1,000m^2) on actual metered energy use and carbon emissions. The proposed title for this scheme is the Property Energy Efficiency Rating Scheme (PEERS).

Therefore the choice of refrigerant type impacts the energy performance, carbon emissions and embodied carbon of an air conditioning or heat pump system. It should therefore be a significant factor in system choice. The long-term implications of the decision can also be financial, given that the F Gas Regulations continue to lower the availability of higher GWP refrigerant. No client wants to be left with an air conditioning or heat pump system that cannot be easily and cost-effectively maintained because the refrigerant is expensive and difficult to purchase.

4. Working with low-GWP refrigerants

The choice of air conditioning system will impact the type of refrigerant that can be applied, and vice versa. The continued push to lower-GWP refrigerants is likely to diverge across the different applications and markets leading to significant changes. This progression may even open manufacturers and specifiers to consideration of A3 (flammable) refrigerants for certain applications.

For example, we can categorise refrigerants as low density or high density. Low density refrigerants include R1234ze and R513A are useful in screw compressor and Turbocor systems. On the other hand, low density refrigerants such as R32 and R454B are good for use in inverter-driven systems and fixed speed applications respectively. There are also natural refrigerants such as carbon dioxide and propane to consider in modern systems. The table below gives an indication of some of the important low-GWP refrigerant characteristics.

Low Density Refrigerants	Characteristics
R1234ze (GWP 7, HFO)	■ Zero environmental impact ■ Small reduction in capacity ■ Efficiency remains the same ■ Increase in cost ■ A2L refrigerant
R1234ze (GWP 7, HFO)	■ Reduced environmental impact ■ Negligible change in efficiency and capacity when using same components as R134a ■ Cost neutral ■ A2L refrigerant

High Density Refrigerants	Characteristics
R32 (GWP 675)	■ Efficiency remains the same ■ Capacity increases ■ Technology only available for small inverter-driven compressors ■ Cost neutral ■ Specified due to availability of small DX compressors using inverters to manage higher discharge temperature
R454B (GWP 466)	■ Increase in efficiency ■ Small increase in capacity ■ Technology only available for larger, fixed-speed compressors ■ Cost neutral ■ Can be used as a ‘drop-in’ for R410A chillers ■ Specified due to ready availability of components for manufacturer of cooling equipment

Natural Refrigerants	Characteristics
R744 - CO_2 (GWP 1)	■ Naturally occurring and safe (non-flammable) ■ Widely used as refrigerant in cars and also available in HVAC equipment (e.g., heat pumps) ■ Cost-effective ■ High pressures required in systems using R744, so must be designed in and not used as a replacement
R290 - Propane (GWP 3)	■ Used in industrial refrigeration for many years; known domestically in use for outdoor heaters and cookers ■ Low GWP ■ Non-toxic ■ Good thermodynamic properties, making it highly energy efficient in systems ■ Flammable

In the next five to ten years, we are likely to see a mix of refrigerants coming onto the market. For example, a switch to hydrocarbon refrigerants for split systems and small heat pumps. For VRF and larger split systems, A2L refrigerants seem a more likely option; and HFOs for chillers and heat pumps. And carbon dioxide (CO_2) is already used as a refrigerant for hot water heat pumps such as Mitsubishi Electric's Ecodan QAHV.

New refrigerants and safety requirements

As the industry adopts new refrigerants, there are new safety implications to consider. As REFCOM points out: "The downside to lowering the GWP of a gas tends to be the increasing flammability or related issues".[5]

The table below gives some indication of relative GWP and flammability designations. The refrigerant R410A has been widely used in the industry for many years and has been popular because of its stable performance as a refrigerant. However, its higher GWP (2088) means that it will shortly be phased out and replaced with low-GWP alternatives, including natural refrigerants such as carbon dioxide (CO_2 or R744)

Refrigerant	GWP	Safety Class ISO 817; Ped (EU)
R1234ze	7	A2L (mildly flammable)*
R513A	631	A1 (non-flammable)
R1234yf	4	A2L (mildly flammable)
R454b	466	A2L (mildly flammable)
R32	675	A2L (mildly flammable)
R290 (Propane)	3	A3 (higher flammability)
R744 (CO_2)	1	A1 (non-flammable)
R410A	2088	A1 (non-flammable)

Notes: *For storage and transportation purposes R1234ze is effectively A1 because it is non-flammable below 30°C. However, the official safety classification is A2L and it should be handled with that in mind.

The levels of flammability are indicated by use of designations such as A1 (non-flammable) and A2L (mildly flammable). These are terms adopted from the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) that are recognised globally. 'Mildly flammable' indicates that the refrigerant is difficult to ignite, has a relatively low energy release and a low flame spread.

All refrigerant-using projects must have a DSEAR (Dangerous Substances and Explosive Atmosphere Regulations) risk assessment carried out at an early stage by a qualified person.

Furthermore, use of refrigerants is also impacted by the Standard BS EN378: Refrigerating systems and heat pumps. The Standard relates the size of an occupied space with the amount of refrigerant allowed within that space. This is dependent not only on the size of the space, but also the type of refrigerant. One of the requirements of BS EN378 can be that refrigerant leak detection is installed (which can increase project costs).

For example, BS EN378 restricts the amount of A2L refrigerants that can be used in occupied spaces, which can make the application of R32-based VRF systems in hotels, for example, challenging unless a hybrid VRF system is applied (see below).

However, in recognition of the changing landscape of refrigerant types, in February 2022 the European Commission announced a review of EN378. The proposal is to explore new standards on safety and use with the objective of smoothing the way for the application of low-GWP refrigerants in future.

RECOVERY, RECYCLING, RECLAIMING

These three terms are often used in relation to refrigerants and the maintenance of air conditioning systems. It is useful to understand what they mean. It is important to note that recovery, recycling, and reclamation should only be carried out by properly certified personnel who are certified under REFCOM or a similar scheme.[6]

1. RECOVERY.

Recovery involves collecting the refrigerant from a system and storing it in an approved container. This can be carried out during maintenance or at the system's end-of-life.

The correct equipment must be used to carry out recovery (particularly in the case of A2L refrigerants such as R32).

2. RECYCLING.

This refers to the re-use of certain refrigerants after they have undergone a basic cleaning process to remove oil, water vapour and particulate matter.

3. RECLAIMING.

Means processing a refrigerant to return it to a state where it will match the performance of a 'virgin' refrigerant. The process is usually carried out by a manufacturer.

5. Air conditioning and heat pump systems that use low-GWP refrigerants

Over the past decade, air conditioning manufacturers have extended the range of low-GWP options for specifiers, making it possible to find the right solution for most building types.

For example, Mitsubishi Electric has developed several chiller options which use low-GWP refrigerants such as R32 or HFO 1234ze. Designing a product around a refrigerant ensures that the equipment makes the most of those characteristics, ensuring excellent energy efficiency and robust performance.

For specifiers considering VRF, the low-GWP R32 refrigerant is also available. One way to avoid the requirements of EN378 for leak detection within occupied spaces is to opt for a hybrid VRF (HVRF) approach. This keeps the R32 refrigerant between the outdoor unit and hybrid branch controller box (often located in a restricted access area) only, using water as the medium for transferring cooling or heating into occupied spaces.

Not only does R32-based HVRF remove the need for leak detection, but it also uses significantly less refrigerant than a traditional VRF system. As a result, the overall carbon footprint of the equipment is reduced, and ongoing maintenance costs (including replacement of refrigerant) are also reduced.

The HVRF system is also highly flexible, making it an excellent choice for Cat A to Cat B projects. It's also straightforward to extend the system, providing future options for building owners who need to respond to changing tenant requirements. One example of this is the Mitsubishi Electric City Multi HVRF system which has been installed successfully in a variety of buildings including hotels and offices.

6. The future is low GWP

As we move towards 2030 and beyond, our use of low-GWP refrigerants will increase. However, there are now plenty of options for designers and installers to select that will not only meet the requirements of F Gas Regulations, but that also offer high energy efficiency, easy maintenance, and flexibility for the modern building.

By embracing the low-GWP approach today, it's an opportunity to adopt modern systems that will deliver excellent performance for end-users and building occupants tomorrow.

References

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2. **The European Environment Agency, Fluorinated greenhouse gases 2021**
   https://www.eea.europa.eu/publications/fluorinated-greenhouse-gases-2021

3. **Cooling post news report:**
   F-gas revision promises steeper phase down
   https://www.coolingpost.com/world-news/f-gas-revision-promises-steeper-phase-down/
   (13th March 2022)

4. **CIBSE TM65**
   https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q3Y00000IPZOhQAP

5. **REFCOM Technical Bulletin TB/033 working with lower flammability refrigerants**
   https://www.refcom.org.uk/media/1221/tb_033_refcom-final-amended-table.pdf

6. **REFCOM Technical Bulletin TB/023 Refrigerant Recovery**
   For full details on regulations covering reclamation, recycling and reclaiming see:
   https://www.refcom.org.uk/media/1203/tb_023_refcom-final.pdf

7. **Mitsubishi Electric UK calculations based on refrigerant quota analysis**

To receive a CPD seminar on ‘F Gas Regulations and the Future of Refrigerants’, 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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MITSUBISHI ELECTRIC
Changes for the Better

Telephone: **01707 282880**

email: **livingenvironmentalsystems@meuk.mee.com**
web: **les.mitsubishielectric.co.uk**

@meuk_les
@green_gateway
Mitsubishi Electric Living Environmental Systems UK
Mitsubishi Electric Cooling and Heating UK
mitsubishielectricuk_les
mitsubishielectric2
BLOG thehub.mitsubishielectric.co.uk

UNITED KINGDOM Mitsubishi Electric Europe Living Environment Systems Division
Travellers Lane, Hatfield, Hertfordshire, AL10 8XB, England
General Enquiries Telephone: 01707 282880 Fax: 01707 278881

IRELAND Mitsubishi Electric Europe Westgate Business Park, Ballymount, Dublin 24, Ireland
Telephone: Dublin (01) 419 8800 Fax: Dublin (01) 419 8890 International code: (003531)

Note: The fuse rating is for guidance only. Please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric’s air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

Effective as of August 2022

Green Gateway greengateway.mitsubishielectric.co.uk