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Guidance, Tools and Training for Refrigerant Containment

Refrigerant Emissions and Leakage GN 4 - 2015

Leakage matters:

for service and maintenance contractors

REAL Zero builds on the F Gas Regulation requirements with good practice recommendations. Recently revised and updated, the programme provides free e-learning & downloads covering:

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2: 13 most common leaks
3: Designing out leaks
4: Leakage matters: for service and maintenance contractors
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Leakage matters: The service and maintenance contractor's responsibilities

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A leak of 1 kg of refrigerant could cause the same environmental damage as 30,000 passenger km travelled on a long haul international flight

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Top ten tips for service and maintenance contractors

1. **Put leakage reduction at the top of your list** – don't just find and fix leaks; the end user relies on you to advise on how to reduce leakage and prevent it.
2. **Be proactive** – look for things on site that could lead to or indicate refrigerant leaks developing such as corroded pipework, oil stains, excessive moisture in the area, missing valve caps, corroded seals, poorly supported pipework, excessive vibration, rubbing, unprotected pipe work.
3. **Follow industry good practice** – make sure your engineers know how to leak test effectively. See GN1 on Leak testing, and the REAL Skills Europe training package if you need more help. EC Regulation 1516/2007 persuant to the F Gas Regulations specifies standard leak checking requirements.
4. **Tools and equipment** – make sure your staff have the necessary tools and equipment to leak test and ensure it is regularly maintained. This includes hand held leak detectors, proprietary bubble spray, fluorescent dye solution, suitable equipment for pressure testing for leak tightness.
5. **F Gas Logs** – engineers must fill in the details required in the F Gas refrigerant log at the required intervals for every system where the refrigerant charge is greater than 5 tonnes CO_2 equivalent. If you are holding this on behalf of the equipment owner, keep them informed of their refrigerant use and reasons for any losses that they need to address.
6. **Use F Gas qualified technicians** (and in the UK ideally registered with ACRIB F Gas SKILLcard). Companies also need to be certified. Make sure the end user knows that it's illegal for unqualified persons to handle refrigerants.
7. **Help the equipment owner** to understand their new legal obligations to prevent leakage under the F Gas and ODS qualifications (see the REAL Skills Europe Guidance GN5 on Leakage Matters – for End Users) and ensure your service and maintenance contracts reflect this.
8. **Refrigerant regulations** – Be ready to provide advice on refrigerant phase downs or bans and implications for operators of equipment containing Ozone Depleting Substances or higher GWP HFC refrigerants.
9. **Design issues** – If you adapt the equipment from the original design you must still ensure it conforms to standards and regulations such as PED, EN378 and F Gas/ODS Regulations and carry out a leak tightness test as well as a pressure test during re-commissioning.
10. **Contracts** for service and maintenance should reflect the new legal obligations to leak test regularly, fix leaks, and recheck within 30 days. The contracts should specify who the person is who has "actual power" over the operation of the system as they are the ones that carry the legal obligations for leaking F gases.

1. Introduction

The servicing and maintenance of refrigeration systems is every bit as important as the initial design of the system in respect to the minimisation of refrigerant emissions to atmosphere. Designers will have carefully selected components and configuration not only to comply with the standards and legislation that governs design but to provide maximum efficiency and minimise leakage.

Service and maintenance managers therefore play a crucial role in ensuring that systems operate at their design efficiency and remain leak tight. We all have a part to play in reducing carbon emissions from refrigerating systems. This document is not a definitive guide to your legal responsibilities; rather, it has been produced to highlight your responsibilities directly related to refrigerant leakage.

Reducing leakage reduction also helps to “future proof” systems. The availability of HFC refrigerants is now subject to phase down so it is likely that high GWP refrigerants, including R404A, the R407series and R410A, will soon become scarce. Their cost has already increased significantly. In addition, from 2020 the use of some HFCs such as R404A will be prohibited for servicing large systems.

2. The true cost of leakage

Direct costs

When a catastrophic or complete leakage of refrigerant occurs, somebody will have to accept the direct cost for:

- Labour to fix the repair.
- The cost of new refrigerant.
- Other expenses such as system down time, replacement parts etc.

Indirect costs

If the leak is small, it may go unnoticed for some time, leading to additional indirect costs such as increased energy use.

A plant that is allowed to leak operates less efficiently. It will run for longer periods, often at more extreme conditions, using more electricity.

The environmental impact of leaking refrigerant from a system

Take a look at what happens when just 1 kg of R404A is released. 1 kg R404A is equivalent to driving a van about 20,000 km. This is based on the following assumptions and conversion factors from the UK Carbon Trust website (www.carbontrust.co.uk):

14 km per litre fuel consumption – about right for a small van.

1 litre of diesel is equivalent to 2.67 kg CO_2[1].

R404A GWP = 3922[2], i.e. 1 kg R404A has the same effect as 3,922 kg CO_2.

So… 1 kg R404A = 3,922 kg CO_2 = 20,565 km.

Relating refrigerant to electricity usage:

A mid range Bosch fridge uses 139 kWh per year; 1 kWh of electricity is equivalent to 0.545 kg CO_2[1].

So… 1 kg R404A has the same effect as running a typical fridge for 51 years.

1. UK Carbon Trust conversion factors (publication CTL113 March 2011)

2. EU 517/2014

3. Your legal responsibilities

Who is legally responsible for fixing and preventing leaks?

According to the F Gas Regulation (EU 517/2014), the person having control of the equipment containing the refrigerant i.e. 'the operator', typically a company, carries this legal responsibility. The Regulation defines the operator as follows:

"Operator means the natural or legal person exercising actual power over the technical functioning of the equipment and systems covered by this regulation".

This is usually the end user / owner of the equipment.

Under the F Gas Regulation EU517/2014 contractors "*carrying out the installation, servicing, maintenance, repair or decommissioning of RACHP equipment shall be certified and shall take precautionary measures to prevent leakage of F-Gases*" In addition, article 3 of the Regulation states that "*The intentional release of F-Gases into the atmosphere shall be prohibited where the release is not technically necessary for the intended use."*

The updated ODS Regulations (EC 1005/2009) placed a legal responsibility on 'undertakings operating equipment' containing these refrigerants eg R22. The requirements for undertaking leak testing are broadly similar to those of the F Gas Regulations. However the use of ODS Refrigerants for service and maintenance purposes is now banned and any refrigerant removed (eg during component replacement) must be destroyed and cannot be returned to the system.

The owner may not be aware of their obligations, and the contractor should therefore take reasonable steps to advise the owner of their responsibilities and offer advice on how to achieve compliance, including recommendations for modifications to the system or changes to the maintenance regime.

The greatest area of potential complication is the landlord-tenant relationship e.g. in a leased air conditioned building. In these circumstances, you may need to refer to the responsibilities set down in the lease. This would normally specify which party is responsible for the operation and upkeep of any air conditioning or heat pump system.

Other obligations of refrigerant legislation

The additional obligations include:

a) Regular leak testing

Leak test frequency specified in the Fluorinated Gas (F Gas) and Ozone Depleting Substances (ODS) Regulations*. The table below shows the frequency specified in the revised F Gas Regulation (EU 517.2014) which came into force 1st January 2015. The regime is based on the carbon dioxide equivalent (CO_2 equiv) of the charge, which is simply:*

Charge weight (kg) x GWP.

System charge	Leak test frequency No fixed leak detection	Leak test frequency With fixed leak detection
5* to < 50 tonnes CO_2 equiv. *e.g. 1.27 to < 12.7 kg R404A* *e.g. 2.37 to < 23.7 kg R407A* *e.g. 3.49 to < 34.9 kg R134a*	1 / year (every 12 months)	1 / 2 years (every 24 months)
50 to < 500 tonnes CO_2 equiv. *e.g. 12.7 to < 127 kg R404A* *e.g. 23.7 to < 237 kg R407A* *e.g. 34.9 to < 349 kg R134a*	2 / year (every 6 months)	1 / year (every 12 months)
> 500 tonnes CO_2 equiv. Fixed leak detection must be fitted *e.g. > 127 kg R404A* *e.g. > 237 kg R407A* *e.g. > 349 kg R134a*	Not applicable	2 / year (every 6 months)

If a leak is found it must be fixed without undue delay and the system re-tested at the point of repair within one month.

* 'hermetically sealed system' means a system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair or disposal and which have a tested leakage rate of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure (Article 2 point 11).

For systems which have less than 3 kg HFC charge but more than 5 tonnes CO_2 equiv, the new leak test regime does not come into effect until January 2017.

Further practical guidance on leak testing is available in the Guide to Good Leak Testing and the Guide to 13 Most Common Leaks.

b) Maintaining records

Under the F Gas Regulation a record must be kept for five years for any system containing a charge of more than 5 tonnes of CO_2 equivalent (more than 10 tonnes CO_2 equivalent for hermetically sealed systems).They do not need to be kept on site but must be readily available should an inspector demand to see them. The records must include:

- The quantity and type of each refrigerant installed in each system
- Any quantities of refrigerant added.
- Whether the refrigerant has been recycled or reclaimed, including the name and address of the recycling or reclamation facility and, where applicable, the certificate number.
- The quantity of refrigerant recovered during servicing, maintenance and final disposal.
- Other relevant information including the identification of the company or technician who performed the servicing or maintenance, as well as the dates and results of leakage checks and leakage detection system checks.
- Follow up actions(repairs and repeat leak tests).
- If the equipment was decommissioned, the measures taken to recover and dispose of the F-Gases.

c) Refrigerant recovery

If HFC refrigerant needs to be removed from a system, it must be properly recovered by certified personnel. After recovery, the refrigerant can be reused or sent for reclamation or destruction as hazardous waste. ODS refrigerant recovered must be sent for destruction.

d) Use of certified staff

As a company operating in this area you have legal obligation to employ only certified personnel to handle HFC refrigerants. Commission Regulation EC 303/2008 (currently under revision) establishes minimum requirements and the conditions for mutual recognition for the certification of companies and personnel as regards stationary refrigeration, air conditioning and heat pump equipment containing certain fluorinated greenhouse gases.

The UK approved individual certification is City and Guilds 2079-11 to -14 and Construction Skills J11 to J14 - for more information see http://www.acrib.org.uk/ or https://www.gov.uk/guidance/qualifications-required-to-work-on-equipment-containing-f-gas

From January 2017 information on relevant technologies to replace or to reduce the use of fluorinated greenhouse gases and their safe handling" must be provided to engineers. No re-assessments are required however and existing certificates remain valid in accordance with the terms that they were issued.

e) Labelling

Systems containing F Gas refrigerant must be fitted with a label clearly stating the type and quantity of HFC refrigerant used. See Guide on Designing out leaks; design standards and practices, for further details.

When *recycled* or *reclaimed* HFCs are added to RACHP equipment it should then be labelled as such. A label should show the type of refrigerant and the total quantity contained in the system and any other requirement in legislation (currently under review by the EU).

f) Company certification and registration

Since July 2009 all companies operating in the sector and employing personnel to handle HFC refrigerant must be certified and registered in order to purchase refrigerant, in accordance with Regulation EC 303/2008. Company Certification is required by all contractors carrying out installation and maintenance work. This applies to sole traders as well as limited companies. Refcom, Bureau Veritas and Quidos provide this certification in the UK. More information is available in the UK at https://www.gov.uk/guidance/certification-for-companies-working-on-equipment-containing-f-gas

HFC refrigerants can now only be sold to and purchased by certified companies. Refrigerant suppliers require evidence that contractors are certified.

4. Design and commissioning – your role in preventing catastrophic leaks

Detailed guidance is available in the guide entitled “Designing out refrigerant leaks: Design standards and practices”. This will help designers, specifiers and consultants minimise potential leaks from vapour compression refrigeration systems. Further information can be found in EN 378:2008+2012 – Refrigerating systems and heat pumps – safety and environmental requirements.

Two other legal areas relevant to the minimisation of refrigerant leaks are the:

a) Pressure Equipment Directive (PED)

The European Pressure Equipment Directive (97/23/EC) defines categories of pressure equipment, depending on the pressure and size of the system and the refrigerant used. It specifies design, construction and testing requirements. In the UK this is enacted by the Pressure Equipment Regulations 1999 and Pressure Equipment (Amendment) Regulations 2002 (SI 2002/1267) (PER). Pressure equipment and assemblies placed on the market and put into service in the United Kingdom must comply with these Regulations.

General requirements (Note: this information is based on the UK Regulations)

Subject to the exclusions described below, the PER make it an offence for a ‘responsible person’ to place on the market, put into service or otherwise supply pressure equipment and assemblies above specified pressure / volume thresholds unless:

- They are safe.
- They meet essential safety requirements covering design, manufacture and testing.
- They satisfy appropriate conformity assessment procedures and are accompanied by a declaration of conformity.
- Where necessary they carry the CE marking and other information (in English). Pressure equipment and assemblies below specified pressure/volume thresholds must:
    a) Be safe.
    b) Be designed and manufactured according to ‘sound engineering practice (SEP)’.
    c) Be accompanied by adequate instructions for use; and bear specified markings (but not the CE marking).
- Strength testing of the system – usually achieved using an inert gas such as oxygen-free nitrogen or equivalent. The strength test ensures the integrity of the system. EN378 part 2 clause 6.3 refers to appropriate methods and applicable test pressures.
- Further guidance on pressure testing can be obtained from the European Standard EN 378: 2008 and IOR Guidance Note GN21: Practical issues relating to pressure systems (available from www.ior.org.uk).
- Equipment/component selection – components must meet or exceed set design criteria and certificates of conformance must be obtained from the manufacturer.
- Pipe selection and grading – the choice of refrigerant and the maximum allowable pressure will determine what pipe and grade is chosen.
- The PED plays its part in ensuring acceptable design standards, which in turn, produces well-designed and, more importantly, leak-tight systems.

- The design standards also apply when replacing system components. To ensure leak-free operation repaired or modified systems must be strength and tightness tested.

b) UK Pressure Systems Safety Regulations (PSSR 2000)

These Regulations apply to the UK and set out the duties of owners and users of pressure systems. PSSR 2000 compliance will be required if one or more of the following criteria are met:

- The system contains a relevant working fluid.
- Emotive inputs of 25 kW and above.
- The system contains at least one pressure vessel with a volume of 250 bar / litres or above.

The PSSR is a legal requirement which has implications for helping to reduce leaks. PSSR checks include reporting on the:

- Condition of pressure vessels and where appropriate, the whole envelope, including system pipe work.
- Operation of over-pressure protection devices i.e. manual high pressure safety cut out switches.
- Age and integrity of the pressure relief valves – are they in date and accurately calibrated? The IOR ACOP and BS EN378 Part 4 Annex D clause 6 both recommend calibration/overhaul and re-certification at five year intervals.

The PSSR is an excellent tool to help reduce refrigerant loss. Consider the effects of a manual over-pressure protection device being incorrectly set (too high), or perhaps malfunctioning. In the event of a condenser fan motor burning out, or the water supply to the evaporative condenser being lost, a pressure relief valve opens and a large quantity of refrigerant with a significant impact on carbon emissions is released to atmosphere (remember the Global Warming Potential of R404A is 3,922 times that of carbon dioxide).

Vessel/pipe work condition is also important. Regular inspection might just prevent that old, rusty, un-insulated suction line from rupturing. Pressure relief valves – incorrectly set, or malfunctioning valves may be the reason why your plant always loses a percentage of its refrigerant charge when the ambient temperature reaches 35°C!

For more details see: http://www.hse.gov.uk/pubns/indg178.pdf

5. Maintenance and system monitoring

Regular and appropriate system maintenance is essential to reduce system leakage in the future. Refrigerant leakage can occur at anytime throughout the lifetime of a plant so diligent system maintenance, performance monitoring and reporting to the equipment owner is needed.

This will also help prevent breakdowns, reduce the risk of a catastrophic loss of refrigerant and ensure the equipment operates efficiently. Equipment owners should be encouraged to have in place a reasonable service and maintenance contract which will allow for this monitoring activity as well as essential maintenance and emergency servicing of equipment in order to more effectively manage their refrigerant.

6. Applying industry best practice

As a contractor, you are directly responsible for the skills and site practices of your refrigeration engineers. The UK REAL Zero project (www.realzero.org.uk) highlighted the need for refrigeration engineers to have additional skills to advise equipment owners on ways to reduce refrigerant leakage. These additional skills would allow engineers to:

- Advise how to minimise leakage in new and existing plant through appropriate design, installation and maintenance.
- Survey and leak test existing plant and identify areas where improvements can be made to reduce leak potential, for example by replacing certain components and specifying an appropriate leak test regime.
- Outline legal requirements and responsibilities such as those under the F Gas and ODS Regulations, and provide information on effective and practical compliance.
- Audit compliance and maintenance on a site-by-site basis.

The training in these additional skills is provided by the REAL Skills Europe e-learning programme which offers assessment and accredited CPD (Continuing Professional Development) certification. Students who successfully complete the full training course and satisfy other criteria can gain a CPD Certificate on successful completion of an assessment. See www.realskillseurope.eu for details.

Free e-learning for technicians is available at www.realskillseurope.eu

There is additional published guidance available to help you to apply industry best practice in the field. This includes:

- REAL Zero and REAL Skills Europe Guidance Notes 1 – 6 www.realskillseurope.eu
- UK Environment Agency F Gas Support RAC Guidance https://www.gov.uk/guidance/certification-for-companies-working-on-equipment-containing-f-gas
- More detailed guidance to print off at
- http://www.gluckmanconsulting.com/f-gas-information-sheets/
- IOR Safety Codes of Practice www.ior.org.uk

- IOR Minimisation of Leakage Code of Practice www.ior.org.uk
- BRA Code of Practice for Refrigerant Leak Tightness www.feta.co.uk
- Materials from AREA the European Contractors association http://www.area-eur.be/
- Industry guidance and e-learning on the use of low GWP alternative refrigerants is available at www.realalternatives.eu

7. Working with end users to achieve zero leakage

End users and service contractors need to work together to reduce leakage. It is important that you, as a refrigeration contractor, are pro-active in maintaining a responsible refrigerant management approach and contractual relationship with your clients. You should discuss and implement:

- The requirements of the F Gas Regulations, including leak testing, charge calculation, F Gas labelling and the F Gas log book (a carbon emissions and cost calculator that includes F Gas refrigerant monitoring spreadsheets for up to 10 systems is available from www.realskillseurope.eu)
- Replacement of high GWP refrigerants where necessary with low GWP alternatives – see guides and e-learning available at www.realalternatives.eu
- The requirements of the EU Ozone Regulations related to bans on service and maintenance and requirements to recover and destroy HCFC refrigerants.
- Compliance with safety standards and other design related legislation

Environmental issues are much higher up the corporate agenda than ever before. Many clients now have a corporate and social responsibility to reduce their environmental impact. As a service and maintenance contractor you can help the end user to measure and reduce the environmental impact of their refrigerating systems, both indirect (energy use) and direct (reducing emissions). In addition, the end user will save money and improve the reliability of their equipment. A carbon emissions and cost calculator is available to assist you and your clients in measuring the:

- Environmental cost of loss of refrigerant.
- Long-term financial cost of this loss, increased call outs, and decreased reliability.
- Impact of potential savings.

It will also help highlight practical aspects of the F Gas and Ozone Regulations. You can download it at www.realskillseurope.eu.or www.realzero.org.uk

8. References and sources of further information

- F Gas Regulations – EU 517/2014 Regulation of the European Parliament and of the Council on Certain Fluorinated Greenhouse Gases
- EC Regulation 1005/2009 (replacing 2037/2000) on substances that deplete the ozone layer. Referred to as the Ozone Depleting Substances (ODS) Regulations
- EC 303/2008 Certification of companies and personnel
- Guidance from UK F Gas Support (GEN and RAC series information sheets) available at http://www.gluckmanconsulting.com/f-gas-information-sheets/
- EN378:2008+2012 Refrigerating systems and heat pumps – Safety and environmental requirements available from www.bsigroup.com
- EU Pressure Equipment Directive 97/23/EC
- Pressure Equipment Regulations 1999 (SI 1999/2001) and The Pressure Equipment (Amendment) Regulations 2002 (SI 2002/1267)
- Guidance Note 21 on Practical issues relating to pressure systems available from www.ior.org.uk
- The British Refrigeration Association Joining of Copper Pipework for Refrigeration Systems – www.feta.co.uk
- EC Regulation 1516/2007 standard leak checking requirements
- Good practice guide for the detection of refrigerant leaks available from http://www.cetim.fr/cetim/fr/Boutique/Librairie/Publications/Good-practice-guide-for-the-detection-of-refrigerant-leaks

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