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# Designing out leaks: design standards and practices

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# Designing out refrigerant leaks: Design standards and practices

The Institute of Refrigeration, working with the Carbon Trust, brings you REAL Zero – Refrigerant Emission and Loss Zero. The aim of this project is in the title – zero refrigerant loss. The project offers practical assistance to everyone involved in purchasing, designing, installing, servicing, maintaining and owning refrigeration equipment to help them reduce leaks.

## Top ten tips for designers and specifiers

1. **Put leak reduction at the top of your list** – leakage causes increased energy use and increased carbon emissions, there are many whole life cost models to help make a convincing argument. New systems should last 20+ years so reducing the potential for leakage from the outset will have a significant long-term impact.
2. **Design standards** – new systems should be designed to EN378:2008, the IOR Minimisation of Leakage Code of Practice and the PED. Even if you are making changes to an older installation, you should review the installation and recommending essential upgrades so it can conform to these standards.
3. **Capping valves** – consider caps that can't be completely removed from the system or valves with sealed steams that are not dependent on caps.
4. **Access to pipework** – where possible avoid routing pipework in concrete or ceiling voids if there is no access to the whole section of pipework. If you can't access it, you can't test it for leaks.
5. **Pipework joints** – use brazed or welded joints wherever possible. Do not use flared joints unless absolutely necessary. Check brazing standard, use qualified brazing personnel, and minimise the number of joints. Poor joints are often difficult to identify visually.
6. **Eliminate or reduce vibration and stress** – excessive vibration or inadequate pipework support will weaken joints and lead to leakage in the future. Also, make sure pipework is protected from impact.
7. **Fixed leak detection systems** are mandatory for systems containing over 300 kg of HFC refrigerant, and recommended in EN 378 for many smaller systems. They should be included in specifications for relevant systems.
8. **System register and labelling** – new equipment must by law be handed over to the customer suitably labelled and with a system register identifying key items such as the type and total charge of refrigerant.
9. **Specify service and maintenance** – correctly specified regimes will help to prevent leaks developing and ensure that any that do occur are fixed rapidly.
10. **Specify installer qualification standards** – use qualified installation personnel to ensure that installations are carried out competently to minimise leakage over the life of the system.

## Introduction

An example of good practice in pipework

The main objective of this guide is to provide information on aspects of design and installation standards that prevent or reduce refrigerant leakage.

In order to reduce carbon dioxide emissions, it is vital that the initial design of the refrigeration system gives priority to eliminating potential cause of leaks. Direct carbon emissions take into account the impact of refrigerants if leaked to atmosphere, and indirect carbon emissions take into account energy use associated with running refrigerating equipment. Getting the design right in the first place will reduce both aspects of these emissions and will prevent problems in the long run.

This document has been produced specifically as an aid to consultants, designers and specifiers. End users may also find it a useful addition to their design specifications. It is not intended to be a definitive guide to the design of RAC systems; rather, it offers guidance on a practical approach to field practice at the time of publication.

### 1. Minimise the refrigerant charge

Refrigerant loss potential is directly linked to the amount of refrigerant in the system. The designer should always aim to maximise the specific refrigerant charge, i.e. the ratio of design cooling capacity to mass charge of refrigerant. End users should ensure that this is taken into account when comparing system options.

In practice, refrigeration systems sometimes hold an amount of refrigerant above and beyond what is required in a liquid receiver to satisfy a varying cooling load. This could lead to excessive refrigerant loss in the event of a catastrophic leak. In addition, minor leaks may go unnoticed until the “buffer” refrigerant charge has been dissipated.

The commissioning team should be informed of the exact refrigerant charge to avoid overcharging the system with refrigerant.

### 2. System construction

**a) Minimise the number of mechanical joints and seals**

A large proportion of refrigerant leaks are caused by the failure of mechanical joints and fittings. Care should be taken to avoid unnecessary joints and access points. Preference should be given to welded or brazed fittings. Brazing or welding should only be carried out by appropriately trained, certified engineers.

Where flared joints are necessary (e.g. for small filter driers), flare solder adaptors should be specified.

**A Schrader badly fitted into the end of a poorly sealed copper pipe**

**b) Piping fittings and construction**

Pipe work will depend on the type and size of the installation, refrigerant type and cost. Steel pipe has superior mechanical strength and is resistant to vibration and work hardening in comparison with copper tube.

Copper pipe is lighter and is easier to bend and join. Joints should be carefully made, particularly when brazed. It is good practice to purge an inert gas such as oxygen free nitrogen to prevent oxides (scale) forming on the inside of the pipe.

**c) Pipe bracketing**

**Poorly laid out pipework on the ceiling void of a chill store**

Refrigerant pipework represents a risk of leakage if it is damaged or inadequately supported. Designers should therefore take great care in pipe routing to ensure it cannot be walked on or damaged easily. Where this is not practicable, the pipe work should be adequately protected and warning labels should be positioned accordingly.

Consideration must be given to the minimisation of the effects of liquid hammer and vibration when designing piping layouts.

**Incorrectly installed vibration eliminator**

**d) Capping valves**

Capped stop valve to the right of the photo with the control actuator to the left

Uncapped valves, especially Schraeders, can lead to long-term, low level leakage. Make sure that specification includes a requirement for all valves to be capped before handing over a system to the client. Consideration should be given to supplying caps that are attached to the valve, e.g. with a chain, so that they cannot become separated.

## 3. Pressure relief valves

Pressure relief is a necessary design safety consideration. The pressure relief valve and its exhaust must be adequately sized. Dual-port inlet valves are preferred as these allow rapid changeover of the pressure relief valves with minimal interruption to the system.

It is feasible to install internal pressure relief valve between the compressor discharge and suction. The pressure setting of this valve must be above the manual HP cut-out pressure of the system but below the main PRV vent to atmosphere.

BS EN378 Part 4 Annex D clause 6 recommends that external pressure relieve devices are checked on site every five years. However, guidance should be provided by the manufacturer taking into account the operating environment.

## 4. Installation practice

Installation work should only be undertaken by competent personnel working under appropriate supervision. The F Gas Regulations lay down new qualifications which apply to those involved in installation and commissioning of refrigeration and air conditioning systems. It also requires that all companies employing refrigerant handling personnel be certified from July 2009 in order to purchase refrigerant.

During construction, pipe work and fittings must be protected from dirt and moisture. Systems should be purged with nitrogen to prevent oxide build-up inside the pipe. The pipe work should be securely bracketed, especially with regards to the small bore pipe.

The system should be properly evacuated to ensure minimal moisture content prior to strength and tightness pressure testing with oxygen-free nitrogen (OFN).

## 5. Fixed leak detection systems

The Fluorinated Gas (F Gas) Regulations dictate that systems with 300 kg or more refrigerant will have a fully operational fixed leakage detection system present. If fitted to systems between 30kg and 300kg, the frequency of checks can be halved.

The requirements for refrigerant detectors are also laid down in BS EN 378-3:2008. In essence for all A1 refrigerants (such as HFCs) this means that a refrigerant detection system is required in the machinery room where the system charge is greater than 25 kg or in any location where the maximum concentration of the refrigerant could exceed the practical limit (The practical limit of the refrigerant indicates the allowable refrigerant charge related to the smallest human occupied space as defined in EN 378:2008).

## 6. Commissioning tests

It is important that the system is confirmed as clean and leak free as part of the commissioning process. Prior to running the refrigeration system, the system is subject to the following pressure tests:

**Strength testing of the system** – Usually achieved using an inert gas such as oxygen-free nitrogen. The strength test ensures the integrity of the system. BS EN378 part 2 clause 6.3 refers to appropriate methods and applicable test pressures.

**Leak tightness testing** – An initial tightness test (typically at 10% of the allowable pressure) is usually undertaken before the strength test. This ensures that there are no major leaks on the plant prior to undertaking the strength test. The full tightness test is undertaken after the strength test. BS EN378 part 2 clause 6.3 refers to appropriate methods and applicable test pressures.

**Leak test fluids** – The standard most popular fluid used throughout the refrigeration industry for pneumatic tightness testing is oxygen-free nitrogen, commonly referred to as OFN. Should there be a leak in the system, it will be necessary to find the exact location of the leak. The use of soap bubbles may not be appropriate in a complex piping system. In this instance, a mix of helium (tracer) and OFN or hydrogen (tracer) and OFN is used, with specific detectors for hydrogen or helium used to pinpoint the leak.

**Checking for leaks** – During the tightness test, all joints should be checked for tightness using either a leak detecting bubble spray or an ultrasonic detector. Where a trace of helium or hydrogen has been used, an electronic leak detector can be used.

**Length of the test** – The tightness test pressure should be held for at least one hour; a longer period may be appropriate for larger systems where a fall in pressure due to leaks may not become quickly apparent.

**Rechecking** – If leaks are identified during the tightness test they should be located and fixed. A further leak tightness test is performed and repeated until satisfactory results are obtained.

The European Safety Standard EN 378: 2008 details how these tests should be carried out.

## 7. Documentation and hand over

It is a statutory requirement to provide the equipment owner with certain documentation (such as EC declaration of conformity as required by the PED, or a system log book as required by the F Gas Regulations). This is an important communication tool from the designer / installer to enable the end user to understand the system design and prevent problems such as leakage occurring in the future.

**a) Commissioning data recorded should include:**

- Details of pressure and tightness tests.
- The refrigerant and lubricant used and the mass or volume of the refrigerant charge.
- Safety device settings such as pressure relief valves, high and low pressure cut-outs and any temperature based protective arrangements.
- Full load running currents and supply voltages for compressor drive motor(s), where applicable, and for other drive motors on the plant.
- Design and actual operating pressures and temperatures.
- Any other relevant information.

Commissioning data should represent the best operational settings of the system achievable by the commissioning specialist. For this reason, commissioning records are important in performance monitoring of the plant, these records being used to assess how operational parameters are being sustained in use. These records should be kept for the life of the plant.

**b) F Gas refrigerant records**

Records must be kept throughout the life of the plant and should be completed by a certified person. They include full details of the initial refrigerant charge , leak tests and repairs, particulars of additional top-up charges and of any removal of refrigerant from the system. Details should include, for any top-up charges, notes of the cause(s) of loss of refrigerant, where found, and of remedial actions taken. A sample F Gas record is available from www.defra.gov.uk/fgas

**c) Labelling of new equipment containing HFCs**

All new equipment must be manufactured or installed with an appropriate label and instruction manuals containing information about F gases contained in the system in English from 1st April 2008. The label must be clearly legible and remain securely in place throughout the life of the product. It must include the wording "Contains fluorinated greenhouse gases covered by the Kyoto Protocol", identify the refrigerant by abbreviated chemical name e.g. R410A, R134a, specify the quantity of HFC refrigerant in kilograms (must include the manufacturer's original charge, any fluorinated greenhouse gases added on site and the total quantity.

The label should be placed in a way which ensures visibility to installation and servicing technicians. For any system with separate indoor and outdoor sections connected by refrigerant piping, the label information must be placed on that part of the equipment which is initially charged with the refrigerant. Suitable locations for the labels are on, or adjacent to, existing nameplates or product information labels, or adjacent to servicing access locations.

Hermetically sealed equipment containing HFC refrigerant must also be labeled with the wording "Hermetically Sealed". This is defined as: 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.

## 8. References and sources of further information


- F Gas Regulations – EC 842/2006 Regulation of the European Parliament and of the Council on Certain Fluorinated Greenhouse Gases
- R22 Phase Out and F-Gas Regulations available from www.ior.org.uk
- Guidance from F Gas Support available at www.defra.gov.uk/fgas
- BS EN378:2008 Refrigerating systems and heat pumps – Safety and environmental requirements available from www.bsigroup.com
- Pressure Equipment Regulations 1999 (SI 1999/2001) and The Pressure Equipment (Amendment) Regulations 2002 (SI 2002/1267)
- The British Refrigeration Association Joining of Copper Pipework for Refrigeration Systems – www.feta.co.uk