Site Surveys & Advice on

Alternative Refrigerants & Leakage

Contents

Table 1. Refrigerant leak rates

Type of Equipment	Typical Range in Charge Capacity (kg)	Installation Emission Factor (% of initial charge)	Operating Emissions (% of initial charge/ year)	Refrigerant remaining at disposal (% of initial charge)	Refrigerant recovered (% of remaining charge)
Domestic Refrigeration	0.05 - 0.5	1.0%	0.3%	80%	99.0%
Stand-alone Commercial Applications	0.2 - 6	1.5%	2.0%	80%	94.5%
Medium & Large Commercial Applications	50 - 2,000	2.0%	11.0%	100%	95.0%
Transport Refrigeration	3 - 8	1.0%	8.0%	50%	94.0%
Industrial Refrigeration (inc. food processing and	10 - 10,000	1.0%	8.0%	100%	95.0%

Welcome to the REAL Alternatives Europe Blended Learning Programme

This booklet is part of a blended learning programme for technicians working in the refrigeration, air conditioning and heat pump sector designed to improve skills and knowledge in safety, efficiency, reliability and containment of alternative refrigerants. The programme is supported by a mix of interactive e-learning, printed training guides, tools, assessments for use by training providers and an e-library of additional resources signposted by users at www.realalternatives.eu

REAL Alternatives has been developed by a consortium of associations and training bodies from across Europe co-funded by the EU Lifelong Learning Programme, with the support of industry stakeholders. Educators, manufacturers and designers across Europe have contributed to the content. The materials will be available in Dutch, English, French, German, Italian and Polish.

Real Alternatives Europe programme modules:
1. **Introduction to Alternative Refrigerants - safety, efficiency, reliability and good practice**
2. **System design using alternative refrigerants**
3. **Containment and leak detection of alternative refrigerants**
4. **Maintenance and repair of alternative refrigerant systems**
5. **Retrofit of existing systems with low GWP alternative refrigerants**
6. **Checklist of legal obligations when working with alternative refrigerants**
7. **Measuring the financial and environmental impact of leakage**
8. **Tools and guidance for conducting site surveys**

You can study each module individually or complete the whole course and assessment.

www.realalternatives.eu

Co-funded by: Lifelong Learning Programme

More information is available in the on line reference e-library.

Throughout the text of each module you will find references to sources of more detailed information. When you have completed the module you can go back and look up any references you want to find out more about at www.realalternatives.eu/e-library. You can also add extra resources such as weblinks, technical manuals or presentations to the library if you think others will find them valuable. Module 5 provides a complete list of relevant legislation and standards referred to within the programme.

Register your interest in alternative refrigerants at

www.realalternatives.eu to receive updates, news and event invitations related to training, skills and refrigeration industry developments.

You can use and distribute this material for individual training

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Background to the programme and how it was developed.

This leaning programme was developed as part of a two-year project led by a consortium of six partners from across Europe funded by the EU Lifelong Learning Programme. It was designed to address skills shortages amongst refrigeration, air conditioning and heat pump technicians related to the safe use of alternative refrigerants. It provides independent and up to date information in an easy to use format. The project consortium included training and professional institutes as well as employer representative bodies. Stakeholders drawn from employers, manufacturers, trade associations and professional institutes also contributed learning material, advised on content and reviewed the programme as it was developed. The six consortium partners were:

- Association of European Refrigeration Air Conditioning and Heat Pump Contractors
- Associazione Tecnici del Freddo, Italy
- IKKE training centre Duisburg, Germany
- Institute of Refrigeration, UK
- Limburg Catholic University College, Belgium
- London South Bank University, UK
- PROZON recycling programme, Poland.

Module 8 –

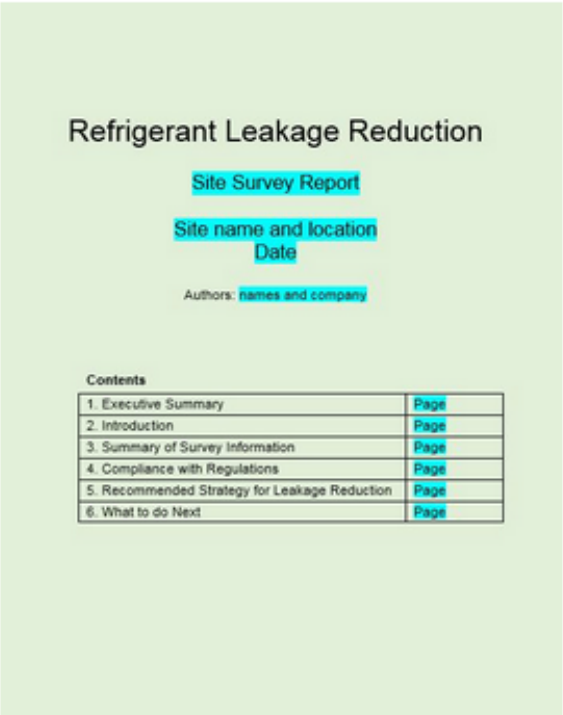
Reducing Leakage of Alternative Refrigerants through Site Surveys and Advice

This Guide (8 of 8) covers Tools and Guidance for those who wish to provide a service to customers by conducting site surveys and giving advice on containment strategies. It provides an introduction to this topic. It does not replace practical training and experience. Throughout the Guide you will find links to useful information, templates, tools and documents from a range of sources that have been peer reviewed and are recommended technical guidance if you would like to find out more about these topics.

The guide shows how information from site surveys should be structured and recorded, so that it can be used to develop an effective leak reduction strategy. Advice is included on the preparation of reports and recommendations using appropriate tools and templates.

You should ready Guides 1 to 7 before starting this Guide or using the tools recommended. On successful completion you should be able to:

- Undertake effective site surveys;
- Assess how a system can be improved to reduce leak risk;
- Assess leakage risks and the potential for leakage reduction;
- Calculate the refrigerant charge in a system using a charge calculator and other methods;
- Collect and evaluate site survey data using the recommended site survey record sheet ;
- Provide advice and recommendations to customers on reducing refrigerant leakage at their sites;
- Write a practical site survey report for customers;
- Evaluate the effectiveness of site surveys and follow up actions to reduce leakage and contain refrigerant.



Refrigerant Leakage Reduction

Site Survey Report

Site name and location
Date

Authors: names and company

Contents

1. Introduction to Site Surveys

Aim of Site Survey

The aim of the site survey is to gather information about the RAC equipment:

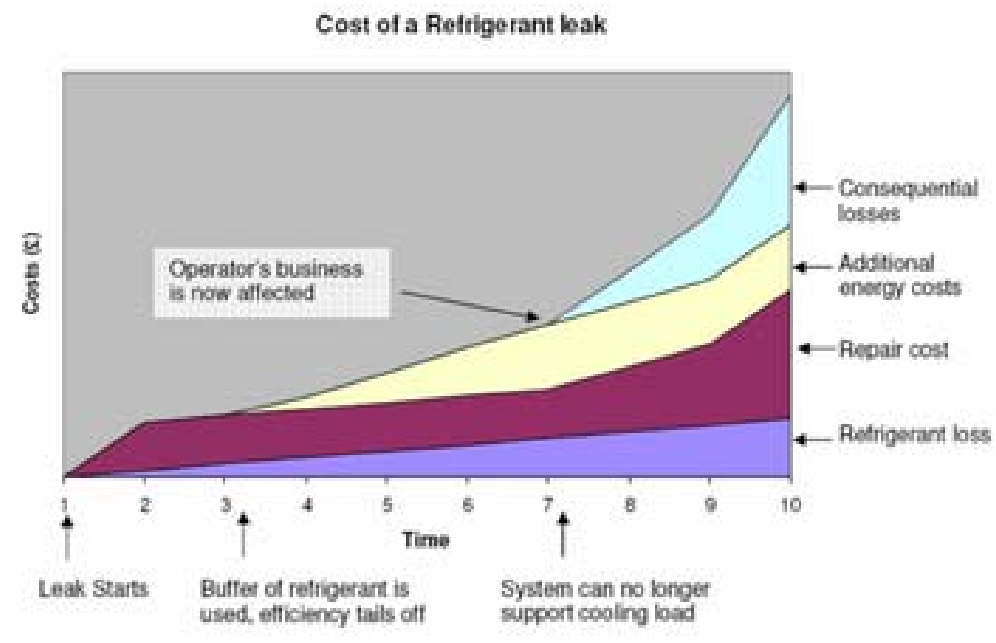
- Its age and condition;
- Its level of maintenance;
- Current leakage and leakage potential;
- Historical leakage points.

This information, coupled with generic information provided in the REAL Alternatives guides, will enable you to develop a strategy to reduce leakage from the systems surveyed. The tools and templates that are provided as part of this module will help you to record the information collected and to generate your report and recommendations.

These surveys are particularly beneficial on systems which often have a high leak rate including:

- R744 central plant such as that used in many supermarkets;
- Other systems where the evaporator is remote from the condensing unit (which would potentially use R717, R744, R32 or R1234ze);
- Split air conditioning systems (including VRV and VRF systems which would potentially use R32).

Equipment which is predominantly integral ("plug in") will not generally have a high leak potential so it is not usually worthwhile including them in this process. Many close coupled systems such as chillers also generally have a low leak rate.

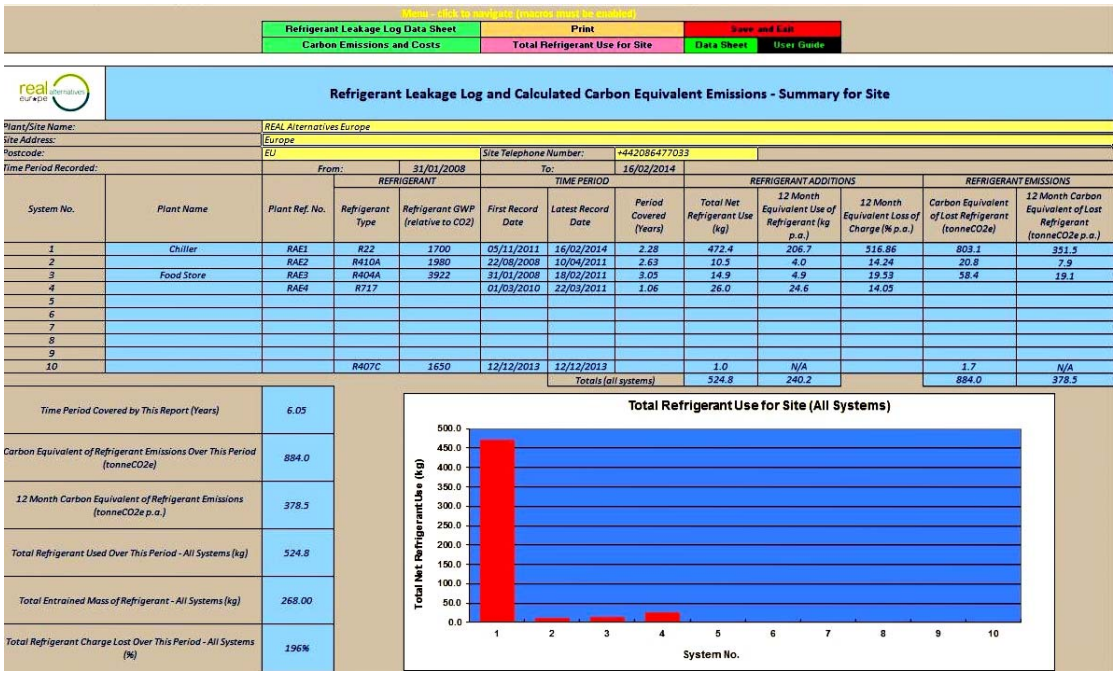


2. Site Survey Procedure

General

A typical site survey procedure is as follows:

- Identify potential sites for survey, e.g. with existing customers or end users you have identified who would benefit from this service;
- Outline to the customer the process and potential outcome;
- Assemble information about the site, including the refrigerant usage logs and maintenance records (if available);
- Carry out the survey;
- Consider how leakage can be reduced on the site – use information from Guides 1 to 7;
- Prepare a strategy for the customer to reduce leakage;
- Arrange a follow up meeting with the customer to discuss the strategy and how best to implement it.



Menu - click to navigate (macros must be enabled)

Refrigerant Leakage Log Data Sheet | Print | Save and Exit

Carbon Emissions and Costs | Total Refrigerant Use for Site | Data Sheet | User Guide

Refrigerant Leakage Log and Calculated Carbon Equivalent Emissions - Summary for Site

Plant/Site Name: REAL Alternatives Europe

Site Address: Europe

Postcode: EU | Site Telephone Number: +442086477033

Time Period Recorded: From: 31/01/2008 To: 16/02/2014

System No.	Plant Name	Plant Ref. No.	REFRIGERANT		TIME PERIOD			REFRIGERANT ADDITIONS			REFRIGERANT EMISSIONS	
			Refrigerant Type	Refrigerant GWP (relative to CO2)	First Record Date	Latest Record Date	Period Covered (Years)	Total Net Refrigerant Use (kg)	12 Month Equivalent Use of Refrigerant (kg p.a.)	12 Month Equivalent Loss of Charge (% p.a.)	Carbon Equivalent of Lost Refrigerant (tonneCO2e)	12 Month Carbon Equivalent of Lost Refrigerant (tonneCO2e p.a.)
1	Chiller	RAE1	R22	1700	05/11/2011	16/02/2014	2.28	472.4	206.7	516.86	803.1	351.5
2		RAE2	R410A	1980	22/08/2008	10/04/2011	2.63	10.5	4.0	14.24	20.8	7.9
3	Food Store	RAE3	R404A	3922	31/01/2008	18/02/2011	3.05	14.9	4.9	19.53	58.4	19.1
4		RAE4	R717		01/03/2010	22/03/2011	1.06	26.0	24.6	14.05		
5												
6												
7												
8												
9												
10			R407C	1650	12/12/2013	12/12/2013		1.0	N/A		1.7	N/A
						Totals (all systems)		524.8	240.2		884.0	378.5

Time Period Covered by This Report (Years)	6.05
Carbon Equivalent of Refrigerant Emissions Over This Period (tonneCO2e)	884.0
12 Month Carbon Equivalent of Refrigerant Emissions (tonneCO2e p.a.)	378.5
Total Refrigerant Used Over This Period - All Systems (kg)	524.8
Total Entrained Mass of Refrigerant - All Systems (kg)	268.00
Total Refrigerant Charge Lost Over This Period - All Systems (%)	196%

example of a refrigerant use recording report

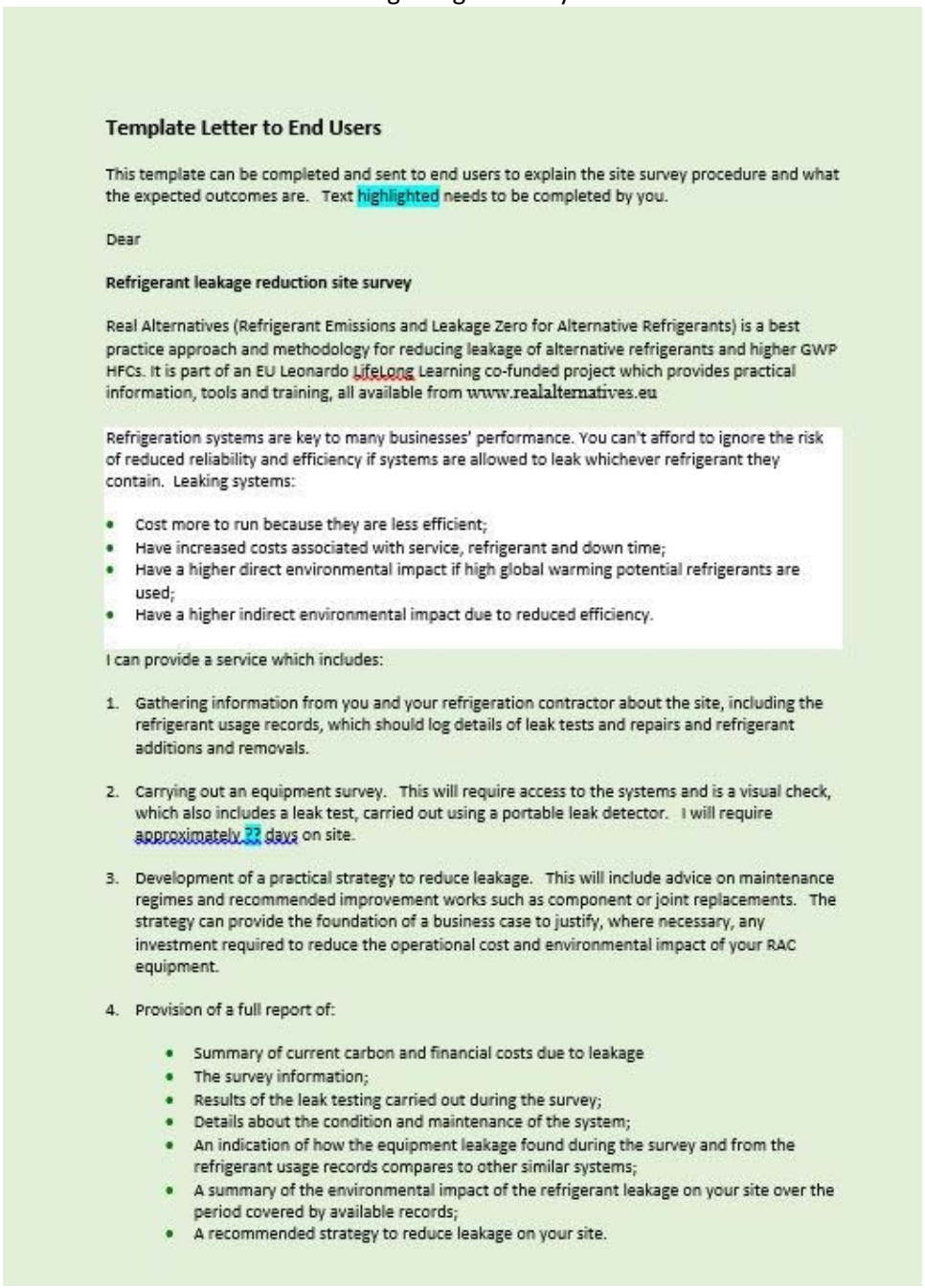
Explaining the process

In order to gain access to refrigeration sites it is important that end users understand the benefits of the survey and how it will help them improve system performance and reduce the costs and the impact on the environment of the RAC equipment. There is a template for a survey contact letter in the link which:

Download a Template www.realalternatives.eu /downloads

- Introduces REAL Alternatives concepts;
- Highlights the importance of leakage reduction, whatever the refrigerant;
- Explains the process and the access to the RAC equipment and information that will be required;
- Outlines the potential benefits and how these will be reported.

The template letter can be adapted to your own requirements, but it is recommended that the information and content is not changed significantly.



Template Letter to End Users

This template can be completed and sent to end users to explain the site survey procedure and what the expected outcomes are. Text highlighted needs to be completed by you.

Dear

Refrigerant leakage reduction site survey

Real Alternatives (Refrigerant Emissions and Leakage Zero for Alternative Refrigerants) is a best practice approach and methodology for reducing leakage of alternative refrigerants and higher GWP HFCs. It is part of an EU Leonardo LifeLong Learning co-funded project which provides practical information, tools and training, all available from www.realalternatives.eu

Refrigeration systems are key to many businesses' performance. You can't afford to ignore the risk of reduced reliability and efficiency if systems are allowed to leak whichever refrigerant they contain. Leaking systems:

- Cost more to run because they are less efficient;
- Have increased costs associated with service, refrigerant and down time;
- Have a higher direct environmental impact if high global warming potential refrigerants are used;
- Have a higher indirect environmental impact due to reduced efficiency.

I can provide a service which includes:

1. Gathering information from you and your refrigeration contractor about the site, including the refrigerant usage records, which should log details of leak tests and repairs and refrigerant additions and removals.

2. Carrying out an equipment survey. This will require access to the systems and is a visual check, which also includes a leak test, carried out using a portable leak detector. I will require approximately ?? days on site.

3. Development of a practical strategy to reduce leakage. This will include advice on maintenance regimes and recommended improvement works such as component or joint replacements. The strategy can provide the foundation of a business case to justify, where necessary, any investment required to reduce the operational cost and environmental impact of your RAC equipment.

4. Provision of a full report of:

    - Summary of current carbon and financial costs due to leakage
    - The survey information;
    - Results of the leak testing carried out during the survey;
    - Details about the condition and maintenance of the system;
    - An indication of how the equipment leakage found during the survey and from the refrigerant usage records compares to other similar systems;
    - A summary of the environmental impact of the refrigerant leakage on your site over the period covered by available records;
    - A recommended strategy to reduce leakage on your site.

Carrying out the survey

The survey is a visual check of the system plus a leak check and it is this survey that will form the basis of your site report and leakage reduction strategy. To complete the report you will need to use the site survey record workbook to collect the data and the template site survey report to write your report.

Site Survey Record and report from www.realalternatives.eu /downloads

The site survey report template which you will use to draft your report is self explanatory. Most of the information to be included will be available from:

- The visual check of the system, which will include an indirect assessment of the level of refrigerant charge;
- The refrigerant usage records (F Gas log for R32);
- General questioning of site staff regarding the level of reliability and historical problems with the site;
- A leak check using an electronic leak detector.

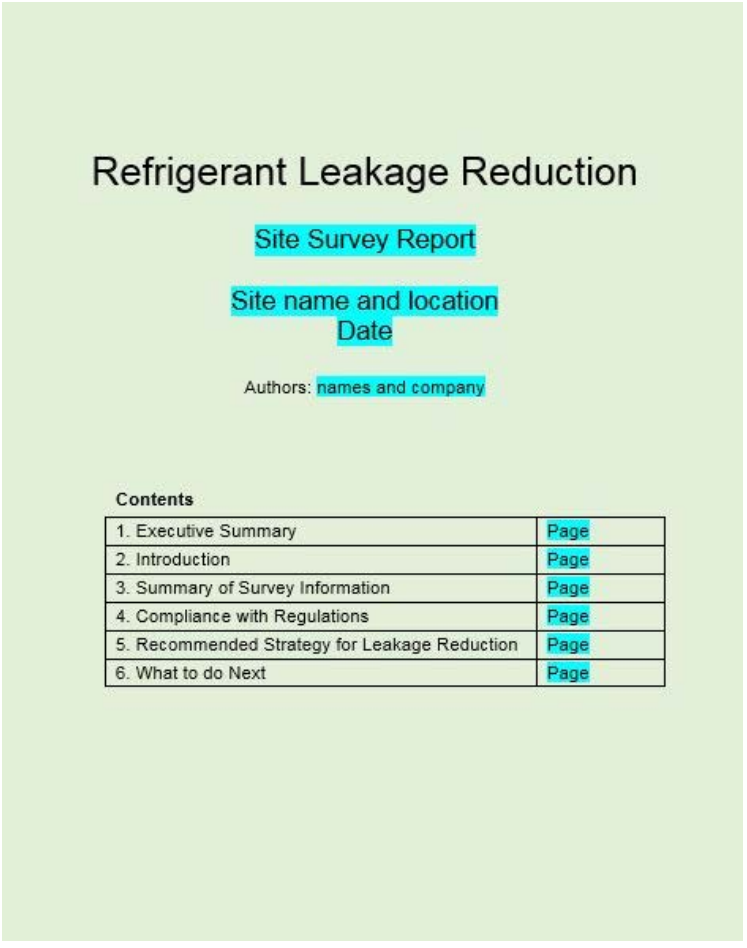
You may need to estimate the refrigerant charge if this is not available. Details on how to do this are provided in Appendix 1.

The survey includes a leak test of the system. This is not intended to be a full leak test unless required by the end user. However, it should be possible to check most joints. You should:

- Use a handheld electronic leak detector which is safe and sensitive for the refrigerant;
- Check it against a reference leak to ensure it is accurate;
- Leak test as many joints as you can easily access, including common leak points such as pressure switches and pressure relief valve vent lines.

REAL Alternatives Module 3 Leak Testing

You will need to use the site survey record workbook to collect the data required for the survey. You can either print out the site survey record workbook to fill out manually on site, transferring the data to the spreadsheet at a later date; or complete the spreadsheet electronically during the survey.



Refrigerant Leakage Reduction

Site Survey Report

Site name and location
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Contents

1. Executive Summary	Page
2. Introduction	Page
3. Summary of Survey Information	Page
4. Compliance with Regulations	Page
5. Recommended Strategy for Leakage Reduction	Page
6. What to do Next	Page

Importance of correct refrigerant charge

It can be useful to relate refrigerant leakage to the refrigerant charge size (also called entrained volume) to provide a leak rate as an annual loss percentage. For example a leak of 20 kg a year in a system with an ideal charge of 40 kg is a 50% annual refrigerant loss. This allows systems to be bench marked and comparisons made to average leak rates so problem systems can be highlighted and targeted.

The correct charge amount is the minimum charge required for the system to run with sub cooled liquid at the entry to all expansion devices throughout the entire range of load and ambient conditions.

Some systems contain more refrigerant than required – the excess refrigerant is held in the high pressure liquid receiver. In the event of a leak the excess refrigerant is lost before the leak results in insufficient liquid in the liquid line (e.g. seen as flashing in the liquid line sight glass) and the performance drops. The system is not technically over charged because it does not result in liquid backing up in the condenser with a subsequent increase in condensing pressure. But the excess refrigerant is not required and increases the potential direct environmental impact in the event of a leak.

Some systems are undercharged because they were not charged with the correct amount of refrigerant during commissioning or service. This is often the case when systems are charged to a full liquid line sight glass when the system is not fully loaded. The system appears adequately charged at low load, but when the load increases, demanding more liquid refrigerant, it is not available.

Systems fitted with high pressure liquid receivers have a significant margin between being undercharged and overcharged.

3. Preparing a Strategy for Containment

The following topics are those which you could potentially include in your strategy. Not all of these will be relevant to every system, and there may be other equipment specific information which you can add.

Background to the strategy with key points from the survey:

- Current and historical leakage;
- Current standard of service and maintenance and its impact – positive and negative – on leakage;
- Age and condition of equipment;
- Compliance with the F Gas regulation (for R32).

Recommendations for improved service and maintenance, including:

- Modifications to the current maintenance scheme or a new maintenance regime where necessary;
- Increase in the frequency of leak testing and the type of leak detection equipment used;
- A complete service if necessary, for example to carry out a thorough leak test, cap valves and replace minor components and joints.

Recommendations for re work or replacement of components or systems, possibly including:

- Pipe work improvements;
- Joint changes, e.g. from mechanical to brazed joints;
- Components changes;
- System replacement;
- Improved access.

You will need to use the following information to develop a practical strategy:

- Historical and current leakage information;
- Current level of service and maintenance;
- Compliance with F Gas regulation if relevant;
- Type, age and condition of equipment;
- Potential for leakage.

These are covered in more detail in the following sections, with general recommendations for improvements from which site specific advice can be produced.

Leakage Records

Historical and current leakage information

This comprises information from the refrigerant usage log and your own leak checking during the survey. From this information you should be able to determine:

- Annual leak rate as a percentage of system charge;
- Leakage points, and in particular problem areas where leaks have recurred;
- Reasons for Leaks – external damage, catastrophic failure or gradual loss of refrigerant;
- Whether leak test has been carried out in accordance with the F-Gas regulations (R32) and / or are appropriate for the plant.

Reasons for leaks vary. Where leaks have been caused by damage from an external source, for example, a fork lift truck, you need to identify vulnerable areas and recommend protection. Catastrophic leaks are usually a result of stress, for example in pipe work. To identify the potential for catastrophic leaks you need to examine pipe routing, support and vibration elimination. Smaller leaks have many causes as outlined in the illustrated guide to 13 common leak points (GN2). You should refer to this guide for solutions to these types of leaks. Further information about solutions to leaks can be found in the other Real Alternatives modules. EN378 also provides guidance which should help prevent catastrophic leakage.

REAL Skills Guide to 13 on common leak points

Current level of service and maintenance

The standard of service and maintenance will be obvious from a visual check of the system and examination of service records. Maintenance is vital to minimise refrigerant leaks. The maintenance regime should be appropriate to the age, condition and type of system. Refer to training Guide 3 for detailed information about maintenance to minimise leakage, and adapt this information for the recommended strategy.

REAL Alternatives Guide 3 on Leak Testing

In addition to good maintenance, good service practice is essential. This includes basic good practice such as:

- Capping valves;
- Changing gaskets when covers, flanges etc are removed;
- Changing pressure relief devices if they have operated;
- Checking and changing seals when necessary.

Where leaks have occurred on the system you have surveyed you could refer to the REAL skills guide to 13 common leaks available in the Additional Resources section for solutions and include these in the strategy

Compliance with the F Gas Regulation

The system operator (usually the end user) is responsible for complying with the F Gas Regulations although under the revised Regulations there are new obligations on those carrying out Service and Maintenance as well (refer to the AREA summary of requirements for contractors available in the Additional Resources page of this Module).
The leakage reduction strategy must recommend a regime in compliance with the F Gas regulation for R32 and any other HFC refrigerant in use, but this should be seen as a minimum standard – for many systems more frequent leak detection is beneficial. This is especially so for systems:

- With many joints;
- Which have mechanical joints such as flares;
- Which historically have a high leak rate (e.g. R744 central plant systems);
- With open drive compressors.

Type, age, condition of equipment and potential for leakage

You will need to consider the age and condition of the equipment when developing the strategy for leakage reduction. It is less likely to be cost effective to make investments in improvements to systems which are near the end of their life. You should consider access to equipment – if access is difficult maintenance is less likely to be carried out.

This may also be a health and safety issue – this is a consideration which will change the balance of investment vs. pay back.

Potential for leakage

In addition to examining current and historical leakage, you should also examine the equipment for future potential for leaks. This includes considering:

- The effect of vibration and whether vibration is correctly eliminated;
- Pipe routing and support;
- Whether pipes can chafe;
- The potential for external damage;
- The types of joint used.

4. Reporting on leakage reduction strategies

Preparation of reports and recommendations

Good clear reporting is essential if the strategy you develop is to be implemented.

The report should include:

- The general impact of leakage and specifically which refrigerants have the greatest impact, but remember that refrigerant leak reduction is important for all refrigerants;
- Background information on the Real Alternative project;
- Indication of typical leak rates for the type of equipment surveyed and whether this equipment is better or worse than similar typical systems;
- How the survey was conducted and key findings, including photos;
- An evaluation of the adequacy of current refrigerant usage records;
- The recommended strategy for reducing leakage;
- A business case for reducing leakage where applicable;
- What to do next.

You should follow up the report with a meeting with key personnel where possible to provide practical advice on how to implement the strategy and work out an action plan. A follow up survey is often beneficial to check the success of the strategy.

Appendix 1, Estimating the Refrigerant Charge Weight

The correct charge can be calculated from:

- The quantity of refrigerant held in each evaporator and condenser (usually available from the manufactacturer in kg or, as a volume, litres).
  plus
- The volume of the liquid line, condensate line, (between condenser outlet and recciever inlet,) and any other pipework which contains liquid refrigerant.
  plus
- The capacity or volume of the liquid receiver at 25% full and other vessels which contain liquid refrigerant.

It is not usually necessary to consider the volume of the pipe work and vessels which contain only refrigerant gas at this will be a very small proportion of the total charge.

There is also a refrigerant calculator and guidance note on calculating refrigerant charge produced by DEFRA in the UK which provides an approximate charge size from simple information about the system (see link from e-library).

DEFRA F Gas Support Refrigerant calculator and guidance notes

There is no assessment associated with this Module.
This module is designed for information purposes only.

5. Additional Resources

This guide is designed as an introduction to the topic of preparing leakage reduction strategies. To find out more you can explore some of the resources below. These are produced by related projects or specialist associations. All material has been peer reviewed by our panel to ensure it provides good quality technical advice and information, which is more detailed than we can provide in our e-learning programme. Inclusion as a link does not imply endorsement of produce and there is no commercial links with any of the companies referred to. All are available from www.realalternatives.eu/e-library

Essential Downloads and Templates for Site Surveys
Refrigerant Tracking Software
Site survey record
Template client letter
Template site report

Environmental impact
Refer to REAL Alternatives Module 1 – Introduction to Alternative Refrigerants

Real Skills Europe Guidance
GN1: Guide to good leak testing
GN2: Illustrated guide to 13 common leaks
GN3: Designing out leaks: design standards and practices
GN4: Leakage matters: the service and maintenance contractor's responsibility
GN5: Leakage matters: the equipment owner's responsibility
Environmental, Cost and Legal Aspects of Refrigerant Leakage Copeland Select 7.7 Software

Efficiency
A series of End User Guides covering Efficiency of Refrigeration plant

Safety
Refer to REAL Alternatives Module 1 – Introduction to Alternative Refrigerants
Carbon Trust fact sheet CTL018, Energy and conversion factors available from

F Gas Requirements
AREA Guide for Contractors
Tool for helping to calculate volume of refrigerant in a system www.realalternatives.eu/app/images/Tools/fgas-refrigerant-calculator.xls

6. What Next?

This is the final guide in the REAL Alternatives Programme Series.

To explore the other guides in the programme please see www.realalternatives.eu

If you have any feedback or suggestions about the programme please contact us at www.realalternatives.eu/contact-us