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BRITISH REFRIGERATION ASSOCIATION

Code of Conduct for carbon reduction in the retail refrigeration sector

Best practice guide

Contents

Introduction

This document is the Best Practice Guide for the Code of Conduct for carbon reduction in the retail refrigeration sector (the Code).

Code of conduct for carbon reduction in retail refrigeration

- **Rationale**
- **Best Practice Guide**
- **Technical Specification**

It is the second in a suite of three documents that make up the Code and contains the best practices that have been developed by each of the four working groups:

- training and skills
- containment
- buildings
- testing and inspection.

The Best Practice Guide contains all of the best practice recommendations, together with a short description of what they involve and references to any further supporting information. It is aimed at technical staff, capable of implementing the recommendations directly or through the teams that they manage.

How to use this document

The best practices have been divided into the four chapters in line with the working group areas.

Each chapter contains an introduction to the working group, explains the key issues addressed and the scope of the best practice advice, followed by a set of recommendations.

This Guide should be used in conjunction with the Code's Technical Specification document, which provides further information and signposting for all of the references assigned to the best practices.

Document scope

This Best Practice Guide assumes that a basic level of legal compliance is already in place for the areas highlighted. Therefore, it does not make significant reference to activities that are legal requirements. It is assumed that readers will already be compliant with the following:

European requirements

- EC Regulation No 842/2006 on Certain Fluorinated Greenhouse Gases
- Regulation (EC) No 852/2004 on the hygiene of foodstuffs
- The European Regulation on Substances that Deplete the Ozone Layer
- The Pressure Equipment Directive (97/23/EC)

UK requirements

- City and Guilds 2079
- Construction Skills J11
- The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (SI 2009/1348)
- The Confined Spaces Regulations (SI 1997/1713)
- The Control of Asbestos Regulations (SI 2006/2739)
- The Construction Design and Management Regulations 2007 (SI 2007/320)
- The Fluorinated Greenhouse Gas Regulations (SI 2009/261)
- The Food Hygiene (England) Regulations 2006 (SI 2006/14)
- The Food Hygiene (Scotland) Regulations 2006 (SSI 2006/3)
- The Food Hygiene (Wales) Regulations 2006 (SI 2006/31 (W.5))
- The Food Hygiene Regulations (Northern Ireland) 2006 (SR 2006 No 3)
- The Hazardous Waste Regulations (England and Wales) 2005
- The Lifting Operations and Lifting Equipment Regulations (SI 1998/2307)
- The Management of Health and Safety at Work Regulations (SI 1999/3242)
- The Manual Handling Operations Regulations (SI 1992/2793)
- The Personal Protective Equipment at Work Regulations (SI 1992/2966)
- The Pressure Equipment Regulations (SI 1999/2001)
- The Pressure Systems Safety Regulations (SI 2000/128)
- The Working at Height Regulations (SI 2005/735)

1. Training and skills

Working group introduction

Background

This section of the Code provides guidance and identifies best practice for those with responsibility for ensuring that the skill level of individuals and the training to achieve the necessary skill level is set at the appropriate standard.

This section is a key area because the skill level of an individual determines the:

- understanding to be able to read and correctly interpret the other sections of this guide
- ability to put the recommendations and best practice into practical application in a real site installation.

To work in line with this section of the Code means that:

- a level of understanding is held that provides a framework for **SAFE** design, installation and management of the project, and that the installation will be operated and maintained in a SAFE manner
- the installation can be expected to achieve the best expected **EFFICIENCY** due to correct design, commissioning, operation and maintenance
- **RELIABILITY** can be expected in accordance with the purchaser's specification, including the practical minimum of leakage, operation without unexpected intervention and downtime, and meeting life expectancy.

The focus of the training and skills working group was to determine the formal skills and assessment through qualification that this industry should work to, with a practical view of where the standards are today and the 'aspiration level'. The formal qualifications must be augmented by the practical skills and experience that are vital in ensuring best practice. This Best Practice Guide highlights the skills and experience that are needed to sit alongside the formal qualification route.

An assessment has been made of the duties that a refrigeration engineer may need to carry out. The assessment has been generalised to allow for the diversity of systems that may be encountered and the scope of work that may be required, which can range from the mechanical refrigeration element through to a complete installation, including all electrical and control specialisations and interfaces.

The training and skills working group consists of 11 members. A full list of members is provided in the Appendix.

Scope

The original scope of this section was to include design, installation, commissioning, operation, and service and maintenance. However, a number of additional key interfaces were recognised as being vitally important to achieving the goals described above. Hence, the working group decided to include these in an additional element - project management.

The best practice is aimed at the type of system used by the food retail business - including smaller convenience store installations that use remote condensing equipment, supermarket and hypermarket systems, and light industrial (food processing). It does not include larger systems that are often found at distribution centres or larger food processing installations.

Aims and objectives

The aims and objectives of the training and skills working group are to:

- provide the organisations in the retail refrigeration sector with a best practice guide to work to when identifying training needs and the standard they should aim to achieve
- provide those who specify and purchase systems with a set of best practices that they can reliably use to procure systems that will be safe, reliable and energy efficient
- provide the operators of refrigeration systems with a best practice guide to help them ensure that operation is performed reliably, and with due regard to safety and efficiency.

Target audience

The training and skills best practices are designed to be used by those involved across all phases of the life cycle of retail refrigeration systems including design, project management, operation, and service and maintenance. They provide guidance to individuals on the best practice skills and qualifications that they should be looking to attain. They also serve as advice to organisations about the qualifications and experience they should be demanding from their contractors.

Best practices

1.1 Design

The refrigeration system designer plays a vital role in ensuring that systems are designed for maximum refrigerant containment, low energy use and high reliability. Training and ongoing development of the skills of designers is essential to ensure that supermarket designs constantly improve and incorporate new, efficient technologies.

No	Name	Description
1.1.1	**Policy on design**	Contractors shall have a clear policy on selecting and training design engineers, and training requirements for the design process. The focus should be on recruiting and training design engineers who have the skills and knowledge to design refrigeration systems that have zero refrigerant leakage, are energy efficient, have low maintenance requirements and achieve the end-user targets for temperature control and cabinet availability/loss in sales. REALZero provides a number of guides that can assist with policy, including 'Leakage Matters for Contractors', 'Guide to Good Practice in Leak Testing' and 'Illustrated Guide to 13 common leaks'.
1.1.2	**Prerequisite qualifications and evidence**	The engineer with design responsibility shall be at minimum a chartered engineer, and shall have at least 5 years of relevant experience.
1.1.3	**Competencies and ability to apply in practice**	All design engineers shall demonstrate the following competencies, either through qualification or proven experience: • understand customer specification, designs and performance specifications (further information is provided by the IOR/BRA Guides to Good Commercial Refrigeration Practice (Parts 1-9)) • understand and use industry-standard design software • a relevant knowledge of thermodynamics • understand building design, location and design limitations affecting design, installation and operation of refrigeration plant (further information on these issues can be found in Chartered Institute of Building Services Engineers (CIBSE) Guide B (Heating, Ventilating, Air Conditioning and Refrigeration)) • understand safe design, installation practices, repair and maintenance, decommissioning and environmental design in line with BS EN 378:2008 (Refrigerating systems and heat pumps) • an ability to calculate refrigeration system efficiency and performance through the use of modelling tools such as total equivalent warming impact (TEWI). Further information on TEWI can be obtained from the BRA in its publication 'Guideline methods of calculating TEWI'

No	Name	Description
1.1.3	**Competencies and ability to apply in practice**	• understand system decommissioning and end-of-life waste disposal in line with the Hazardous Waste Regulations • be able to provide system commissioning performance details and requirements • understand the operation of retail display cabinets, air flow, construction, positioning of control sensors, factors affecting performance • understand cabinet selection and the impact of selection on performance and efficiency • understand the basic principles of system control and operation through the application of either mechanical or electronic control systems • understand the required electrical infrastructure and impact of design on peak load demands in line with BS 7671 (2008) – Requirements for Electrical Installations (Institution of Electrical Engineers (IEE) Wiring Regulations) • be capable of considering opportunities to integrate other technologies and services through the application of renewable and sustainable technologies and design (further information on renewable energy technologies is available from the Carbon Trust).
1.1.4	**Continuing professional development (CPD)**	Design engineers shall demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. For engineers not already of chartered status this should be directed towards achievement of Chartered Engineer status. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, the Engineering Council, and through REAL Zero CPD training.
1.1.5	**Validation and audit**	Contractors shall have a policy for validating and auditing the training of designers. This should be based on ISO 9001:2008.

1.2 Installation

Installation engineers play an important role in ensuring that systems have maximum refrigerant containment and high reliability. The skills of engineers should be continually developed and improved to reach this goal.

No	Name	Description
1.2.1	**Policy on installation**	Installers shall have a clear policy on selecting and training installation engineers, and training requirements for the installation process. The focus should be on recruiting and training engineers who have the skills and knowledge to install refrigeration systems that have zero refrigerant leakage and maximum reliability.
1.2.2	**Prerequisite qualifications and evidence**	The responsible person /supervisor shall hold: • Level 3 NVQ certificate in installing and commissioning refrigeration systems • Installation engineers shall hold the following: • Level 2 NVQ diploma in installing and maintaining refrigeration systems • ConstructionSkills Pipework or BRA Brazing Assessment, and Brazing (ConstructionSkills R1 Safe Handling of Refrigerants including Pipework and Brazing) Installations engineers, where relevant, should hold the following: • training in the latest edition of the IEE Regulations (electrical installation engineers only) • ConstructionSkills Basic Refrigeration System Electric (E29) • City & Guilds Hydrocarbon CPD Unit (when available) • City & Guilds Carbon Dioxide CPD Unit (when available). • REAL Zero qualifications. Engineers shall be familiar with: • BS EN378:2008 (Refrigerating systems and heat pumps) • European harmonised standards.

No	Name	Description
1.2.3	**Competencies and ability to apply in practice**	Engineers must demonstrate competencies and abilities in line with the following: • IOR safety codes of practice – for relevant refrigerants • IOR/BRA guides to good commercial refrigeration practice • Pressure Equipment Directive (97/23/EC) • Construction (Design and Management) Regulations • interpretation of system design drawings, method statements, recorded test results and performance requirement • task procedures and risk assessments (further information is provided by the BRA in 'Model statements of task procedure and risk assessment for commercial refrigeration') • Control of substances hazardous to health (COSHH) data – further guidance can be found in 'COSHH – a brief guide to the regulations: what you need to know about COSHH' • Working at Height Regulations • Manual Handling Operation Regulations (further guidance is provided in Getting to Grips with Manual Handling – a short guide) • Personal Protective Equipment at Work Regulations (further guidance is provided by A short Guide to the Personal Protective Equipment at Work Regulations 1992) • Confined Spaces Regulations • Management of Asbestos in the Workplace Regulations • safe use of gas cylinders • understanding of local site health and safety needs.
1.2.4	**Continuing professional development (CPD)**	All installation engineers should demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA and through REALZero CPD training. CPD accredited courses include IOR evening papers, membership of BRA/Heating and Ventilating Contractors' Association (HVCA)/IOR (MinstR or FInstR), REALZero CPD training.
1.2.5	**Validation and audit**	Installers shall have a policy for validating and auditing the training of installation engineers. This should be based on ISO 9001:2008.

1.3 Commissioning

The commissioning process is vital to the efficient operation of a refrigeration system. The expertise and skill of the commissioning engineer should be proven through training and ongoing development of knowledge and skills.

No	Name	Description
1.3.1	**Policy on commissioning**	Contractors shall have a clear policy on selecting and training commissioning engineers, and training requirements for the commissioning process. The focus should be on recruiting and training engineers who have the skills and knowledge to ensure that refrigeration systems are energy efficient, have zero refrigerant leakage, have low maintenance requirements and achieve the end-user targets for temperature control and cabinet availability/loss in sales.
1.3.2	**Prerequisite qualifications and evidence**	Commissioning engineers shall be: • designated a competent person under BS EN 378:2008 (Refrigerating systems and heat pumps)/Pressure Equipment Directive (97/23/EC) • qualified to level 3 NVQ certificate in installing and commissioning refrigeration systems or an alternative relevant qualification (HND/HNC/foundation degree/ engineering degree, etc) or older equivalent/higher-level qualification as foundation level qualification. Commissioning engineers should be familiar with or hold: • Construction Skills Basic Refrigeration System Electric (E29) • Construction Skills Pipework and Brazing (Construction Skills R1 Safe Handling of Refrigerants including Pipework & Brazing).
1.3.3	**Competencies and ability to apply in practice**	Commissioning engineers should be familiar with and capable of applying and interpreting: • IOR Safety Codes of Practice for different refrigerants • IOR/BRA Guides to Good Commercial Refrigeration Practice • BRA 'Model statements of task procedure and risk assessment for commercial refrigeration' • industry updates and guidance notes available from trade associations and professional institutes (for example, the IOR Guidance Notes and Safety Codes of Practice) • relevant European and British standards, regulations and directives • refrigeration system information, including system design drawings, method statements, any recorded test results, performance requirements, etc • system documentation to relevant parties • decommissioning at end of life (further information is provided in the IOR/BRA Guide to Good Commercial Refrigeration Practice, Part 7 – System and component decommissioning and waste disposal

No	Name	Description
1.3.3	**Competencies and ability to apply in practice**	• City & Guilds Hydrocarbon CPD Unit (when available) • City & Guilds Carbon Dioxide CPD Unit (when available) • Air Conditioning and Refrigeration Industry Board (ACRIB) (Construction Skills Certification Scheme (CSCS)) skill card, including F-Gas certificate, City & Guilds 2079 or ConstructionSkills J11-14.
1.3.4	**Continuing professional development (CPD)**	Commissioning engineers should demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, and through REALZero CPD training. CPD accredited courses include IOR evening papers, membership of BRA/HVCA/IOR (MinstR or FInstR), REALZero CPD training.
1.3.5	**Validation and audit**	Contractors shall have a policy for validating and auditing the training of commissioning engineers. This should be based on ISO 9001:2008.

1.4 Operation

End users have a vital role to play in the ongoing efficiency of their refrigeration systems. Employee training, and expanding their skills and knowledge can play a vital role in ensuring that cabinets are operated correctly and that any problems are identified early.

No	Name	Description
1.4.1	**Policy on operation**	End users shall have a clear policy on training staff involved in managing and operating refrigeration systems. The focus should be on recruiting and training staff that have the skills and knowledge to ensure that refrigeration systems are energy efficient, have zero refrigerant leakage, have low maintenance requirements and achieve the end-user targets for temperature control and cabinet availability/loss in sales.
1.4.2	**Prerequisite qualifications and evidence**	Relevant seniority to ensure legal requirements and operational recommendations are applied, and five years of senior operational experience.
1.4.3	**Competencies and ability to apply in practice**	Operators shall: • have an understanding of system operation, performance and efficiency, and management. Further information is provided by the IOR/BRA Guides to Good Commercial Refrigeration Practice (Parts 1-9). • minimise refrigerant leakage from the system. Further information on minimising refrigerant leakage is provided by the IOR/BRA Guide to Good Commercial Refrigeration Practice (Part 10), the IOR Code of Practice for the Minimisation of Leakage and the REALZero Guide 'Leakage Matters for End Users' • understand monitored information and be able to interpret and analyse information • be capable of identifying remedial action and instructing contractors to carry out relevant work • be familiar with, and apply, food safety (temperature) regulations – legal and in-house • be familiar with health and safety legislation and guidance • train shop-floor staff to act as energy efficiency champions/teams • designate a leakage reduction specialist or champion who must hold relevant REALZero and/or F-Gas qualifications.
1.4.4	**CPD**	Operators should demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, and through REALZero CPD training. CPD accredited courses include IOR lectures, membership of BRA/HVCA/IOR (MinstR or FInstR), REALZero CPD training.
1.4.5	**Validation and audit**	End users shall have a policy for validating and auditing the training of staff. This should be based on ISO 9001:2008.

1.5 Service and maintenance

Routine service and maintenance is vital for the ongoing efficient operation of a retail refrigeration system. The expertise of the service engineer should be proven through formal training courses and through continual ongoing training to enhance skills.

No	Name	Description
1.5.1	**Policy on service and maintenance**	Contractors shall have a clear policy on selecting and training service and maintenance engineers, and training requirements. The focus should be on recruiting and training engineers who have the skills and knowledge to ensure that refrigeration systems are energy efficient, have zero refrigerant leakage, have low maintenance requirements and achieve the end-user targets for temperature control and cabinet availability/loss in sales. Further information is provided by REALZero in its guides 'Leakage Matters: The service and maintenance contractor's responsibilities', 'Guide to Good Practice in Leak Testing' and 'Illustrated Guide to 13 common leaks'.
1.5.2	**Prerequisite qualifications and evidence**	Refrigeration technicians/service engineers shall be: • designated a competent person under BS EN 378/Pressure Equipment Directive (97/23/EC) • qualified to level 2 NVQ diploma in installing and maintaining refrigeration systems • qualified to ConstructionSkills Basic Refrigeration System Electric (E29) • qualified to ConstructionSkills Pipework and Brazing (ConstructionSkills R1 Safe Handling of Refrigerants including Pipework & Brazing).
1.5.3	**Competencies and ability to apply in practice**	Refrigeration technicians/service engineers, where relevant, shall hold the following: • City & Guilds Hydrocarbon CPD Unit (when available) • City & Guilds Carbon Dioxide CPD Unit (when available).
1.5.4	**CPD**	Service and maintenance technicians should demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, and through REALZero CPD training. CPD accredited courses include IOR evening papers, membership of BRA/HVCA/IOR (MinstR or FInstR), REALZero CPD training.
1.5.5	**Validation and audit**	Service and maintenance companies shall have a policy for validating and auditing the training of engineers and technicians. This should be based on ISO 9001:2008.

1.6 Overarching characteristics/project management

The project manager holds a key role in ensuring that retail refrigeration projects are delivered on time and to specification. The project manager requires a range of skills that should be proven through training and ongoing CPD.

No	Name	Description
1.6.1	**Policy on project management**	All parties shall have a clear policy on selecting and training staff. The focus should be on recruiting and training staff who have the skills and knowledge to ensure that refrigeration systems are energy efficient, have zero refrigerant leakage, have low maintenance requirements and achieve the end-user targets for temperature control and cabinet availability/loss in sales. Further information is provided by REALZero in its guides 'Leakage Matters: The service and maintenance contractors responsibilities', 'Guide to Good Practice in Leak Testing' and 'Illustrated Guide to 13 common leaks'.
1.6.2	**Prerequisite qualifications and evidence**	Level 3 NVQ Diploma in Building Services Engineering Technology & Project Management, or equivalent qualification.
1.6.3	**Competencies and ability to apply in practice**	Refrigeration project managers shall demonstrate an understanding of, or hold a formal qualification in, the following key areas: • project management • tender preparation • team leadership • contract management - ability to interpret formal contract conditions, understand risks and implications (further guidance is provided by the BRA 'Model statements of task procedure and risk assessment for commercial refrigeration') • specification, design (including computer-generated drawings) – all proven through qualification and/or experience and peer review • a detailed knowledge of the main refrigeration system components, in line with specifications including 'Jointing of Copper Pipework for Refrigeration Systems - BRA • building design, location and design limitations affecting the design, installation and operation of refrigeration plant • Construction (Design and Management) regulations • standards and safety regulations applying to refrigeration (further information can be found in the IOR Safety Codes of Practice and the IOR/BRA Guide to Good Commercial Refrigeration Practice, Part 3 - Safety and environmental considerations and standards • health and safety • the basic principles of system control and operation through the application of either mechanical or electronic control systems • the basic principles of applied design in electrical infrastructure requirements with peak-load demands in line with BS 7671:2008 - Requirements for electrical installations.

No	Name	Description
1.6.4	**CPD**	Project managers should demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. CPD accredited courses include IOR evening papers, membership of BRA/HVCA/IOR (MinstR or FInstR), REALZero CPD training.
1.6.5	**Validation and audit**	All parties shall have a policy for validating and auditing the training of staff. This should be based on ISO 9001:2008.

2. Containment

Working group introduction

Background

This section of the Code provides guidance and identifies best practice for better containment of refrigerants in retail refrigeration systems over their operational life.

The operation of refrigeration systems leads to greenhouse gas (GHG) emissions via two main routes:

- indirect GHG emissions associated with the generation of energy used to operate the system
- direct GHG emissions associated with the escape of refrigerants due to leakage or incorrect handling during installation and maintenance procedures.

It is the direct GHG emissions arising from refrigerant leakage that are the focus of the Containment working group.

The global warming potential of hydrofluorocarbon (HFC) and hydrochlorofluorocarbon (HCFC) refrigerants can be up to 4,000 times that of CO_2. In a 'leaky' refrigeration system, the direct GHG emissions from the release of these refrigerants may approach, or exceed, the level of the indirect GHG emissions.

Refrigerants that are properly contained in a system do not contribute to global warming – they only become a problem if they are released to the atmosphere. To reduce the overall GHG emissions from a refrigeration system, it is imperative that the risk of leakage is minimised (regardless of what type of refrigerant is used). The Containment working group was challenged with collating best practice advice that will help to reduce refrigerant leakage, with an overall mission statement of 'zero tolerance to leakage'. The Containment working group consists of 10 members. A full list of members is provided in the Appendix.

Scope

This working group focuses on best practice in refrigerant gas containment across the practices of design, installation, commissioning, operation and service and maintenance. This approach reduces the potential risk of releasing refrigerants in to the atmosphere over the entire operational life of refrigeration systems.

Aims and objectives

The overall objective of this working group was to produce a defined set of best practices that articulates the most appropriate activities necessary to reduce the level of refrigerant leakage and move toward a level of complete containment.

Specifically, this includes the following aims:

- to highlight the importance of refrigerant gas tightness over a system's operational life
- to emphasise the benefits of allowing adequate timescales to ensure a gas-tight refrigeration system
- to detail methods of improving gas tightness over the operational life of a system
- to highlight the potential benefits of longer term more positive client/contractor relationships for large and small end users, and to demonstrate how these relationships can significantly reduce the risk of refrigerant gas leakage.

Target audience

The Containment best practices are designed to be used by those involved across all phases of the life cycle of retail refrigeration systems from design to operation and service and maintenance.

This includes the design and installation of a leak-tight system, commissioning that ensures that the system is operating without refrigerant leakage and an approach to operation and service and maintenance that ensures that any leaks that do occur are identified and addressed as quickly as possible. At each phase, the best practices may be used by the end user or their contractor, for reference or direct application.

Best practices

2.1 Design

Best practice in containment starts with a system design that is aligned with a policy of zero tolerance to leakage. The design team will have responsibility for the following best practice areas.

No	Name	Description
2.1.1	**Policy on design**	Systems shall be designed in line with a robust policy of zero tolerance to leakage, to be delivered throughout their lifetime. The principles of this policy should include minimising the potential for leakage, detecting and repairing leaks quickly, measuring and benchmarking performance, understanding the cost of leakage, and proactively and continuously improving plant performance.
2.1.2	**Design staff skills**	The engineer with design responsibility shall be at minimum a chartered engineer, and shall have at least 5 years of relevant experience. They shall be able to demonstrate an understanding of the importance of refrigerant leakage from, and energy used by, refrigeration systems. Design staff shall demonstrate their ability to maintain and update their training, and achieve a level of competence on current and future technologies, legislation drivers and principles of application through CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, and through REALZero CPD training. CPD accredited courses include IOR evening papers, membership of BRA/HVCA/IOR (MinstR or FInstR), REALZero CPD training. For further information refer to the Training and Skills section in the Code.
2.1.3	**Concept specification**	Designers shall demonstrate that they have considered all available refrigerants suitable for the specific application of the system and selected the system with the lowest overall carbon impact. For example, consideration must be given to lower global warming potential (GWP) refrigerants (that is, R407A/R407F/CO2/hydrocarbons instead of selecting R404A as standard). Further information on refrigerant selection can be found in IOR Guidance Note 18: Refrigerant Selection and System Design – the role of HFCs. A systems approach shall be used for concept specification, taking energy efficiency into consideration. The best system should be selected based on a life cycle or total equivalent warming impact (TEWI) approach, which takes into consideration direct and indirect emissions, as well as revenue and capital costs over a system's life cycle. Further information on TEWI can be found in the BRA guidance document 'Guideline Methods of Calculating TEWI'. The designer shall minimise the need for cooling, since system size, refrigerant charge and leakage will potentially depend on the size and complexity of the system. Further information on how to reduce cooling loads is provided in the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 2 – System Design and Component Selection'. The system shall be designed to operate with a minimum charge level, avoiding the use of large refrigerant receivers. This should be carried out in accordance with the specification BS EN378-1:2008 (Refrigerating systems and heat pumps) and the IOR/BRA 'Guide to Good Commercial Refrigeration Practice Part 10 – Leak Prevention'.

No	Name	Description
2.1.4	**Equipment and component specification**	Designers shall ensure that equipment and component specification is carried out in accordance with the IOR/BRA' Guide to Good Commercial Refrigeration Practice Part 2', and REALZero guide 'Designing out Leaks: Design Standards and Practices'. Specific examples of best practice in equipment and component specification include: • specifying that new equipment must be tested and certified by the manufacturer as strength and leak tested in accordance with BS EN-378: 2008 (Refrigerating systems and heat pumps) • ensuring that, where reciprocating compressors are selected on a pack, they are staged to minimise the number of starts in lower load conditions - consider using inverters • ensuring minimum head pressure at design and allow head pressure to float to the lowest level possible to ensure system stability • ensuring that condenser pipework design allows liquid refrigerant to drain back to the receiver/system under all conditions • specifying independent isolation of split/larger condensers to compensate for refrigerant migration in all ambient conditions • designing plant for minimum vibration.
2.1.5	**Re-use of components**	Any equipment that is re-used from a previous system shall be pressure tested at its original design test pressure. For further information refer to BS EN378-1:2008 (Refrigerating systems and heat pumps). Retrofitting of plant shall be carried out in accordance with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 8 - Refrigerants and Retrofitting'.
2.1.6	**Design for leak detection and repair**	Design shall exceed the minimum requirements of the F-Gas regulations. Further information on meeting and exceeding the requirements of F-Gas is provided by REALZero and by Defra F-Gas Support. Designers shall specify the installation of leak detection over and above the statutory minimum including non-invasive liquid receivers to monitor refrigerant levels. Designers shall ensure that access to the system is sufficient to allow leak testing and repair to be carried out as necessary. Further information is provided in the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 10 – Leak Prevention' and IOR 'Guidance Note 20, Fixed Refrigerant Detection Systems'.

No	Name	Description
2.1.7	**Installation specification**	The design team shall provide the installer with a clear specification for the installation process. This shall be prepared in accordance with the 'Guide to Good Commercial Refrigeration Practice Part 4 System Installation' and RealZero 'Good practice guide 3 - Illustrated guide to common leak points'. Specific examples to be included in the specification provided to the installer include: • all mechanical (threaded) fittings shall have sealing compound applied, once new plant is installed • pulled bends shall be used where allowable, but 1'1/8" should be the maximum diameter used • all joints shall be installed in accordance with ISO/CD 14903, 'Refrigerating Systems and Heat Pumps - Qualification of Tightness of Components and Joints' • systems shall be installed with the minimum number of joints possible • equipment shall be positioned to minimise pipework runs and shall allow ease of access for maintenance and testing. All materials and components to be used shall be clearly defined in the specification. Examples include: • refrigerant copper tube gauge and silver solder content of brazing rod • where pipe diameters are greater than 1'1/8", long radius, pre-formed bends shall be specified • the specification shall state that the installer must identify the position of joints on the outside of insulation using flourescent cable ties • valve caps shall be attached with a chain, and caps for use with Schrader valves shall be hexagonal (so they can be tightened with a spanner), rather than having a knurled finish • flared joints shall be avoided • the number of joints used shall be minimised.

No	Name	Description
2.1.8	**Documentation specification**	Installation drawings provided by the design team shall include reference to all relevant standards. Brazed joints shall be identified on layout drawings, which must be updated to reflect actual location when 'as-installed' design detail is issued. The expected system refrigerant gas charge shall be indicated by applying refrigerant labels to all plant (in line with the Pressure Equipment Directive 97/23/EC). Further information is available from F Gas Support. The specification shall require the installation of visual reminders for contractors and refrigeration engineers to remind them of their leakage reduction and containment responsibilities when working on refrigeration systems (for example, REALZero stickers).
2.1.9	**Intelligent procurement and design**	Guidelines shall be issued to procurement staff to allow them to ensure that systems procured meet sufficient containment standards. A systems approach to procurement and design shall be used, whereby the performance over time is considered and overall life-cycle emissions, including direct/indirect, are evaluated. Validation of design and installation quality shall be undertaken. This can be achieved by clients/client agents/consultants to confirm that the design used is consistent and adheres to the original design specification. For further information, refer to the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 2 - System Design and Component Selection'.
2.1.10	**Performance testing**	The design specification shall specify a performance test as part of the handover procedure. This must ensure that the system is operating in line with the design. The specification shall include a clause which identifies consequential refrigerant losses on all new systems for a period of 12 months.
2.1.11	**Feedback process (installed system to designer)**	Design staff shall communicate regularly with service and maintenance organisations, and take account of feedback from live systems during the design process.

2.2 Installation

Best practice in installation is essential to ensure that the refrigeration system is set up in line with design guidelines and shows zero leakage. The installation team will have responsibility for the following best practice areas.

No	Name	Description
2.2.1	**Policy on installation**	Systems shall be installed in line with a robust policy of zero tolerance to leakage, to be delivered throughout their lifetime. The principles of this policy must include minimising the potential for leakage, detecting and repairing leaks quickly, measuring and benchmarking performance, understanding the cost of leakage, and proactively and continuously improving plant performance. The installation contractor shall sign up and agree to the principles of the IOR/BRA 'Guide to Good Commercial Refrigeration Practice – Part 4, System Installation'.
2.2.2	**Installation staff skills**	Installation team members shall be aware of refrigerant leakage, its impact on the environment and their responsibilities to prevent it. They shall understand best practices in refrigeration installation. For further information, refer to the IOR/BRA 'Guide to Good Commercial Refrigeration Practice – Part 4, System Installation'. All installation engineers shall have achieved a pass mark in REALZero 'Module 3 - Reducing Leakage in New Systems'. For further information, refer to the Training and Skills section in the Code.
2.2.3	**Time planning**	Appropriate time shall be allowed for refrigeration system installation, including sufficient time for pressure testing. This will reduce the risk of having to pressure test a system for a second time.
2.2.4	**Installation drawings**	From the outset of any installation, all designs and isometric drawings shall be accurately adhered to. Installation shall be checked, against design, by the client or their representative.
2.2.5	**Variations from design**	The rerouting of any refrigeration services during an installation shall only be carried out with prior approval from the relevant designer, and after a full redesign and reissuing of the relevant isometric drawings has been completed.
2.2.6	**Installation materials**	Good-quality refrigeration-grade copper pipe (specified to BS EN 12735-1) shall always be used. All products shall be clearly marked for identification and traceability under the Pressure Equipment Directive (97/23/EC). A minimum of 5% silver content shall be used in brazing rod. Contractors that braze copper pipe must present a brazing certificate.

No	Name	Description
2.2.7	**Constructing joints**	Pipework installation shall be installed in accordance with the IOR/BRA 'Guide to Good Practice in Commercial Refrigeration, Part 4 – System Installation' and in accordance with ISO/CD 14903 'Refrigerating Systems and Heat Pumps — Qualification of Tightness of Components and Joints'. When joining different metal types such as copper/steel the appropriate silver solder rod and flux compound shall be used. This should be checked by the client or client's agent. The use of any other alternative type of mechanical jointing systems not listed in the installation specification (for example, flare or lock ring (potentially removing or minimising the need for hot brazing)) shall only be used following approval by the client or their advisor. All pipework, joints, components and equipment shall be readily accessible for leak testing and checking. Where pipework is installed to limited access locations, for example under floors or above asbestos ceilings, the location of pipe joints shall be physically identified on the pipework. Joint location should also be identified on a general arrangement drawing. All threaded mechanical joints shall be sealed using a reliable sealant compound (for example, shut off valve caps, flared connections, rota lock connections). This will minimise the risk of leakage from these areas over the lifetime of the system. During the brazing of copper joints, moisture-free nitrogen shall be purged through the system at a positive pressure. This should be done in such a way that the outlet open end of the pipe run restricts the flow of nitrogen, but still allows the free flow of nitrogen through the pipework generating the positive pressure. This can be achieved by not completely sealing the end. This will minimise the risk of carbonisation within the pipework, which will assist in good brazing-rod penetration and adhesion. Further information is provided in the IOR/BRA 'Guide to Good Practice in Commercial Refrigeration, Part 4 – System Installation'.
2.2.8	**Protection and supports**	All copper pipes shall be mechanically protected to prevent damage. For example, this may include the installation of protective covers to prevent pipes being stood on. Installers shall ensure that no other materials, which could cause mechanical or chemical corrosion, come into contact with the copper pipe at any point (particularly other metals). The installation of mechanical support systems for refrigeration pipe services shall be approached in such a way that all mechanical vibration is eliminated or kept to an absolute minimum. For example, refrigeration-grade copper pipe clips must be used for vertical risers and drops and, for horizontal runs, clips or cushioned protection must be used. When necessary, anaconda type vibration eliminators should be installed. All high-level support systems for copper pipe services shall be positioned to allow full and clear access to all sides of the services, giving the installer a good working position to form the quality brazed joint.

No	Name	Description
2.2.8	**Protection and supports**	Insulated and/or non-insulated refrigeration pipework shall not be installed directly onto any flat surface. An appropriate support system must be used, such as tray and/or cushion protection, to suspend the services above a flat surface. This will allow good, clear access around the pipework during installation and will prevent insulation on the services from being compressed over time. Refrigeration pipework shall not be installed directly on top of electrical cable tray runs. Any copper pipework shall be installed separately above or alongside tray work, using appropriate support systems.
2.2.9	**Audit**	Spot-check auditing shall be undertaken to ensure that compliance to best practice installation methods and specified design performance requirements is adhered to. This should include non-destructive, as well as destructive (that is, removing parts of joints to check brazing penetration quality), methods of checking for joint quality.
2.2.10	**Feedback process**	Installation staff shall communicate regularly with design, commissioning, and service and maintenance organisations, and should take account of feedback from live systems during the installation process.

2.3 Commissioning

Best practice in commissioning ensures that the installed refrigeration system is set up to operate efficiently and with zero leakage. The commissioning team will have responsibility for the following best practice areas.

No	Name	Description
2.3.1	**Policy on commissioning**	Systems shall be commissioned in line with a robust policy of zero tolerance to leakage, to be delivered throughout their lifetime. The principles of this policy must include minimising the potential for leakage, detecting and repairing leaks quickly, measuring and benchmarking performance, understanding the cost of leakage, and proactively and continuously improving plant performance. Commissioning shall be carried out in accordance with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 5 – Commissioning'.
2.3.2	**Commissioning team skills**	Members of the commissioning team shall have an awareness of refrigerant leakage, its impact on the environment and their responsibilities to prevent it. They shall understand best practices in refrigeration commissioning. For further information, refer to the BRA/IOR 'Guide to Good Commercial Refrigeration Practice – Part 5, Commissioning'. Commissioning engineers shall undertake and pass all modules of the REALZero course and qualify as a REALZero Assessor. For further information refer, to the Training and Skills section in the Code.
2.3.3	**Time planning**	Appropriate time shall be allowed for refrigeration system commissioning, including sufficient time for pressure testing. This will reduce the risk of having to pressure test a system for a second time.
2.3.4	**Documentation**	Commissioning staff shall provide certificate documentation to demonstrate proof of operation and show comparison to design. The documentation shall confirm the satisfactory operation of the leak-detection system.
2.3.5	**Audit**	The client, or their representative, shall witness/audit the pressure test process and performance test. The operation of the leak-detection systems (without leaking refrigerant to atmosphere) should be demonstrated by the commissioning engineer to the client or their representative.

No	Name	Description
2.3.6	**Strength and pressure testing**	Strength testing of the whole installation shall be witnessed by a third party in accordance with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 5 – Commissioning' and BS EN 378:2008. Each system shall be pressure tested in line with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 5 – Commissioning' for a minimum period of 12 hours. The pressure test shall be independently validated and documented in line with the best practice code. In the event of a pressure test failure, the leak shall be identified, appropriately repaired and a full 12-hour retest must be carried out. Information on safety is available from the HSE guidance note 'Safety in Pressure Testing'.
2.3.7	**System evacuation and final leak test**	The evacuation procedure shall be carried out in line with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 5 – Commissioning' and BS EN 378:2008. A final gas-tightness check shall be carried out prior to charging any system. A TORR or vacuum pressure gauge shall be fitted at the furthest point of the system to ensure that a vacuum has been achieved at 1.5 TORR or 0.002 bar absolute for a 24-hour period. During evacuation, the system must be capable of pulling a vacuum of 0.5 TORR (0.00066 bar) or less. This shall be tested twice, with the last evacuation pulling 0.5 TORR. The pump should then be switched off for 1 hour. The vacuum must be held prior to being broken with refrigerant. Refrigerant charging should be carried out using best practice as defined by the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 10 -Leak Prevention, and Part 3 - Safety and Environmental Considerations and Standards', and the IOR Code of Practice for the Minimisation of Refrigerant Emissions from Refrigerating Systems. Once a system is fully charged and running, a final leak test shall be undertaken using a handheld mobile leak-detection unit to test all joints. Information on safety is available from the HSE guidance note 'Safety in Pressure Testing'.
2.3.8	**Feedback process**	Commissioning staff should communicate regularly with design, installation, and service and maintenance organisations, and should take account of feedback from live systems during the commissioning process.

2.4 Operation

All aspects of the day-to-day operation of a refrigeration system should be managed in line with a policy of zero tolerance to leakage. Operations staff will have responsibility for the following best practice areas.

No	Name	Description
2.4.1	**Policy on operation**	Systems shall be operated in line with a robust policy of zero tolerance to leakage, to be delivered throughout their lifetime. The principles of this policy must include minimising the potential for leakage, detecting and repairing leaks quickly, measuring and benchmarking performance, understanding the cost of leakage, and proactively and continuously improving plant performance. It must facilitate containment through service engineers, store staff and the store manager. It should include the practice of record-keeping and analysis of performance, as well as education of key stakeholders.
2.4.2	**Operating staff skills**	The store manager and key store staff (for example, the energy or carbon champion) shall have passed REALZero 'Module 1 - Environmental Aspects of Refrigerant Leakage'. The service engineer shall have passed REALZero 'Module 2 – Service and Maintenance'. Visual reminders for contractors and refrigeration engineers shall be displayed to alert them to their leakage reduction and containment responsibilities when working on refrigeration systems (for example, REALZero stickers). For further information, refer to the Training and Skills section in the Code.
2.4.3	**Monitoring leakage performance**	Targets/key performance indicators (KPIs) for continuing leakage reduction shall be set across the entire estate of refrigeration systems and for specific refrigeration systems. REALZero recommendations (for example, flare-nut torque settings) shall be included in the site technical specification documentation to ensure appropriate adjustment information is available to contractors and refrigeration engineers when they work on site. Year-on-year reduction targets shall be set against the previous year's refrigerant usage and/or best performance of similar stores. Service contractors shall exceed the minimum F-Gas Regulations leak-testing requirements to achieve the year–on-year reduction target. Further information is provided in the BRA 'Fact Finder Number 13 - Practical Guide to the F-Gas Regulation'. Refrigerant usage shall be monitored on a monthly basis, setting a monthly reduction target for the current month against a baseline of the same month in the previous year. Tracking in this way will show a monthly trend in refrigerant usage. The operator shall evaluate the overall financial impact of leakage from the system and consider options to mitigate leakage on an annual basis.

No	Name	Description
2.4.3	**Monitoring leakage performance**	The installation of leak detection, over and above the statutory minimum requirements, shall be specified for plant, including non-invasive liquid receivers to monitor refrigerant levels. Reliable handheld leak-detection units, capable of detecting a minimum 5g per year leak rate (supplied with a leak reference bottle) should be used by all service and commissioning engineers.
2.4.4	**Contractor management**	Periodic meetings (monthly or quarterly, as appropriate) shall be held to review leakage reduction and refrigeration containment against agreed targets. If there is a leak, operators should ask the contractor to calculate the cost of leakage in terms of refrigerant, repair and energy. This should form part of the service engineer's report. Realistic and achievable KPIs shall be set for all aspects of contracts. This shall include leakage reduction targets. Contractor feedback on how best to improve performance and containment should be requested by the operator. Proposals that identify value for money for the end user and lower life-cycle costs should be requested. Operators shall investigate reasons for contractor overspends as these may be indicative of underlying problems.
2.4.5	**Remodelling and re-commissioning**	A regular review of remodel plans shall be undertaken to ensure that any works include replacement or refurbishment works for refrigeration equipment that has, historically, had high refrigerant use. During this review, any refrigeration survey detail produced shall include the volume of refrigerant the system has used over its life. This shall be communicated to the service and maintenance provider, and the installation contractor. During remodelling/refitting works, all plant/equipment shall be recommissioned. This ensures that equipment is operating as designed and is running as efficiently as possible.

No	Name	Description
2.4.6	**Energy consumption/ performance**	All available system energy and temperature data shall be regularly reviewed to ensure that energy consumption is consistent and tracks to historical values for equivalent ambient conditions. Irregularities in performance may identify leakage at an early stage. Control system data shall be reviewed to ensure that plant is running within optimum conditions for the type of refrigerant in use. If plant is operating outside of optimum working conditions, this should be escalated to the service team. The lowest possible condensing conditions and highest evaporating conditions shall be maintained to achieve desired performance, product temperatures and energy efficiency. Long-term system performance shall be monitored and cross-checked against commissioning data. Any deviation should be escalated to the service team.
2.4.7	**Asset replacement**	Operators shall have an asset-replacement plan in place. The design specification should indicate appropriate asset replacement/refurbishment cycles. When building asset-replacement plans, all available data and expertise from the client and the service contractors shall be utilised. A good contractor shall understand priority sites and the issues associated with the equipment, and make use of manufacturer specifications and guidance where it is available.
2.4.8	**Incentivise and encourage staff to take action to reduce leakage**	Refrigerant usage reduction shall be a Key Performance Indicator (KPI) for senior management, supervisors and all engineers in the field. All KPIs and usage data shall be shared with all levels of staff involved and praise/ reward should be given where targets are being exceeded.

No	Name	Description
2.4.9	**Record-keeping**	Operators shall hold, and ensure maintenance of, up-to-date records of refrigeration system charges and refrigerant type, including details of refrigerant additions, in accordance with the F Gas Regulations. Further information is available from F Gas Support. Operators shall use data to monitor trends in refrigerant usage against the type of system, location on system, item failed on systems and manufacturer of equipment where leaks occurred. High or irregular leakage rates shall be identified and any issues resolved through escalation to the service and maintenance engineer. Refrigerant usage figures shall be issued and compared against agreed KPIs on a monthly basis. Operators should invest in an administrator to collate an F-Gas data spreadsheet and ensure that regulatory compliance is tracked and exceeded. For best practice, the REALZero 'Electronic F-Gas Log' shall be used. Operators shall set up a record-keeping system for checking all refrigerant orders, particularly the amount of refrigerant requested. This creates a culture of control of refrigerant. A small number of trained staff should be designated to authorise refrigerant purchases (ideally field supervisors).
2.4.10	**Feedback process**	Operation staff shall communicate regularly with design, commissioning, service and maintenance organisations, and should take account of feedback from live systems during the operation process.

2.5 Service and maintenance

Best practice service and maintenance ensures that refrigerant leakage rates are minimised and that, where leaks do occur, they are identified and resolved as quickly as possible. Service and maintenance staff are responsible for the following best practice areas.

No	Name	Description
2.5.1	**Policy on service and maintenance**	Systems shall be maintained in line with a robust policy of zero tolerance to leakage, to be delivered throughout their lifetime. The principles of this policy must include minimising the potential for leakage, detecting and repairing leaks quickly, measuring and benchmarking performance, understanding the cost of leakage, and proactively and continuously improving plant performance. It should set targets for maximum refrigerant leakage rates and for year-on-year improvements. It should specify the minimum qualifications and training requirements for service and maintenance engineers, together with specifications for leak-testing equipment and other support tools. It must set out an agreed maintenance schedule that includes leak detection as an integral part of maintenance, and specifies the frequency, type and number of inspections and tests, the fault resolution/repair processes, the methods of documentation and reporting actions and refrigerant used. Equipment operators and maintenance contractors shall agree a written policy on refrigerant containment that details their respective roles and responsibilities in complying with F-Gas and Ozone Depleting Substances (ODS) Regulations and how leakage risk and leak potential can be reduced through an effective service and maintenance regime. All policies shall be in accordance with the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 6 - System Maintenance and Service' and the REALZero guidance 'Leakage Matters, the Service and Maintenance Contractor's Responsibilities'.
2.5.2	**Service and maintenance staff skills**	Staff shall be made aware of the environmental impact of refrigeration systems, and should understand their organisation's key legal responsibilities and obligations under the F-Gas Regulations and Ozone Depleting Substances Regulations. Service and maintenance engineers shall achieve a pass mark in all four modules of REALZero. They should be qualified as REALZero leakage reduction advisers. For further information, refer to the Training and Skills section in the Code.
2.5.3	**Audit**	An audit system shall be put in place to ensure that service and maintenance records are kept up to date, repairs are being made in a timely manner, and generic reasons for leakage are being identified and resolved.

No	Name	Description
2.5.4	**Know your charge volume**	All on-site engineers shall have access to an instruction manual, schematics and layouts of plant. This will enable them to identify the volume of refrigerant charge in the system at any point. If this information is not available, it shall be estimated using F-Gas Support information sheet (GN5) and an spreadsheet-based refrigerant charge calculator, which are available from Defra F-Gas Support. Equipment shall be labelled with the abbreviated chemical name and quantity of refrigerant (in kg). Further information is provided in the IOR/BRA 'Guide to Good Commercial Refrigeration Practice, Part 6 - System Maintenance and Service'.
2.5.5	**Know your leakage**	Systems shall be tested for leaks on a regular basis and any leaks repaired. Service and maintenance engineers shall review records of refrigerant type and leakage rates and assess any trends in the data. See the REALZero 'Illustrated Guide to 13 Common Leaks' for examples of the most common leak points. Leak testing shall be carried out once a month on all accessible parts of a system, paying particular attention to joints and components. Further information on leak testing is provided in the REALZero 'Illustrated Guide to 13 Common Leaks', and the 'Guide to Good Leak Testing'. F-Gas logs shall be used to record all refrigerant additions and removals, dates of leak tests performed and any faults identified, and repair actions undertaken. Further information on maintaining an F-Gas log in accordance with best practice is available from REALZero.
2.5.6	**Benchmarking and setting targets**	Benchmarking shall be carried out to allow comparison of the refrigerant leakage rates with similar systems in the same organisation, in other organisations or with refrigeration and air conditioning (RAC) sector benchmarks. RAC benchmarks are provided in 2010 Guidelines to Defra/Department of Energy and Climate Change's 'GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors' (Table 48). It should be noted that this paper provides average values for the listed equipment types and organisations should set stretch targets that are lower. Leakage data shall be categorised and recorded by equipment age and type. Further information on recording leakage data is provided by REALZero. Trends in leakage shall be investigated over a period of several years and any issues identified shall be rectified. Benchmarking results shall be used to identify systems with the highest leakage rates and set targets for improvement over the next reporting period. Benchmarking results shall be used to measure the effect of any changes made to the equipment and the maintenance regime.

No	Name	Description
2.5.7	**Use the correct tools**	Leak testing shall be carried out using portable electronic leak detectors. Service and maintenance engineers shall know which type of detector to use, how to use it properly and how to verify that it is working correctly. Detectors shall be serviced at regular intervals. A reference leak shall be used to check that leak detectors are working correctly. Handheld leak detectors should be supplied with a reference leak bottle that will enable this to be carried out. The calibration of a leak detector using a reference leak is described in the REALZero 'Guide to Good Leak Testing'. Service and maintenance engineers shall be aware of the correct settings that should be maintained for the equipment that they are servicing. If any alterations are necessary, original settings should be restored following the service activity. Tools used (for example, personal digital assistants (PDAs), laptops, software and spreadsheets for capturing and analysing data) shall be appropriate for the working environment. Documentation records shall be completed by the service and maintenance engineer before leaving the site. Further information is available from F Gas Support.
2.5.8	**Planned preventive maintenance (PPM)**	A PPM system shall be put in place in accordance with design/manufacturer recommendations. A survey shall be carried out once a month. This could be a standalone survey or part of a regular maintenance schedule. It should include a visual examination of the system for signs of leakage and increased leakage risk (for example, oil stains, ice formation, blocked condensers). The examination shall also consider design or installation issues that might increase leakage potential (for example, high levels of vibration, inadequate supports, poor quality joints). Any such issues shall be investigated further and resolved by the service and maintenance engineer. A detailed leak test shall be carried out at the same time as the monthly survey. If leaks are found, they must be repaired, and the frequency of leak testing increased until the number of leaks found at each inspection has reduced to an acceptable level. Review activity shall be undertaken as part of PPM and shall include analysis of F-Gas and repair logs. Leakage trends should be identified and investigated to measure the impact of changes. Component and system faults should be investigated in detail for evidence of systemic problems.
2.5.9	**Decommissioning**	A robust procedure shall be put in place for the decommissioning of plant to minimise the effects of refrigerant emissions at the end of its useful life. Further information is provided by Defra F-Gas Support.
2.5.10	**Feedback process**	Service staff shall communicate regularly with design, commissioning, service and maintenance organisations, and should take account of feedback from live systems during the service and maintenance process.

3. Buildings

Working group introduction

Background

This section of the Code provides guidance and identifies best practice for the better design and co-ordination of building structures, mechanical services and retail refrigeration systems over their operational life.

The operation of refrigeration systems leads to greenhouse gas (GHG) emissions via two main routes:

- indirect GHG emissions associated with the generation of energy used to operate the system
- direct GHG emissions associated with the escape of refrigerants due to leakage or incorrect handling during installation and maintenance procedures.

The Buildings working group aims to address emissions arising from both of these routes. The group has also targeted the best practices with reference to the BRE Environmental Assessment Method (BREEAM) building assessment and certification scheme for retail buildings, to ensure a consistent approach across industry.

It is often the easy option to design aspects of a building without clear reference to cause and effect on the overall building structure and services design. The Buildings working group has considered aspects of refrigeration system life cycle from design, installation, commissioning and operation through to service and maintenance. In each of these aspects, issues such as energy efficiency, correct use, and life-cycle operation from initial construction have been addressed.

This section of the Code complements and supplements the technical aspects of other sections and provides guidance to associated technical parties that highlights where they can impact on best practice. It also supports and guides the end user in making decisions that will maintain systems in optimum operating condition.

The Buildings working group consists of 10 members. A full list of members is provided in the Appendix.

Scope

This working group focused on best practice in the design of buildings and mechanical services where they impact on the performance of retail refrigeration systems and vice versa. The group has also considered the operator, and the specific considerations that need to be given to maintaining systems at their optimum. This approach can reduce the operational impact of refrigeration plant on the environment by ensuring efficiencies and minimising the potential risk of releasing refrigerants to the atmosphere.

Aims and objectives

The overall objective of this working group was to produce a defined set of best practices that articulates the external influences that a building and its mechanical services can have on a refrigeration installation. The best practices aim to ensure that a co-ordinated approach to building design is adopted, which should ensure that the highest efficiencies are achieved.

The working group focused on the need to use the most appropriate skills throughout the life of a project and ensure that adequate time is allowed to achieve the goals that best practice demands.

Target audience

The buildings best practices are designed to be used by those who provide building and services design, which can impact on refrigeration system performance across all phases of its lifecycle. It includes the operator/end user where the overall life cycle and efficiencies can provide the biggest environmental impact.

Best practices

3.1 Design

Design is the first step in ensuring that buildings and the systems that operate within them are low carbon in nature. The design team will have responsibility for the following best practice areas.

No	Name	Description
3.1.1	**Policy on design**	Buildings and the systems within shall be designed in line with a robust policy of minimising carbon emissions throughout their lifetime. The principles of this policy shall include minimisation of carbon emissions, refrigerant leakage and embodied carbon, as well as measuring and benchmarking performance, minimising waste, understanding the cost of carbon, and proactively and continuously improving plant performance.
3.1.2	**Staff skills and knowledge**	The engineer with design responsibility shall be at minimum a chartered engineer and shall have at least 5 years of relevant experience. Design team staff shall be able to demonstrate an understanding of the importance of reducing carbon emissions and energy use through better building design. The design organisation shall have a framework in place to support related CPD, and design staff should be able to demonstrate regular related CPD. Further information on CPD is available through institutions such as CIBSE, IMechE, IChemE, IOR, BRA, and through REALZero CPD training. For further information, refer to the Training and Skills section in the Code.
3.1.3	**Concept design**	Designers shall be able to demonstrate that they have designed the store and its services for lowest overall impact. A systems approach should be used for selection, enabling selection of the best system based upon a life cycle, TEWI or equivalent approach that considers indirect and direct emissions, as well as revenue and capital costs over the life cycle. Further information on TEWI is provided in the BRA document 'Guideline methods of calculating TEWI'.
3.1.4	**Multidisciplinary approach**	Cross discipline knowledge transfer shall take place throughout the design and shall include minimisation of loads on cabinets and heat load into the store, heat recovery/hot water supply from refrigeration plan, HVAC cooling systems, and air movement and lighting systems. The use of software programs to aid multi-disciplinary installations and reduce conflict shall be specified at the early stages of design. Building information management systems assist with the assessment of all building services and can be used to eliminate conflicts between systems at the design stage. The building envelope shall be designed to minimise heat gain to the space through minimum infiltration into the store and integrity of the building fabric.

No	Name	Description
3.1.4	**Multidisciplinary approach**	Net heating and cooling effects shall be taken into account by the mechanical consultant in the heat-load calculations for the building. For example, spill of cold air from cabinets creates a cold aisle effect in the store. Concept systems of cold air retrieval or aisle heating should be established to overcome this effect. A carbon manager should be employed at the design stage to provide advice on minimising the carbon impact of the proposed plant.
3.1.5	**Energy efficiency of equipment**	System design shall specify the highest possible efficiency of components for full and part-load conditions. Suction/evaporating conditions shall be as high as possible. Design that involves multiple operating conditions shall be avoided. Condensing conditions must be as low as practicably possible for best practice energy efficiency to be achieved. High evaporating temperature cabinets shall be used (large coils), with single evaporating temperatures across the refrigeration pack. The use of heat recovery shall be considered in the design of the refrigeration system (de-superheating to domestic hot water, condensing to hot water for heating/over-door heating/cold-aisle heating). However, condensing conditions shall not be artificially inflated to deliver heat recovery. Consideration shall be given to the use of wet, condensing-based systems. Further information on energy saving technologies can be found in the Refrigeration Road Map produced by the IOR, BRA and Carbon Trust.
3.1.6	**Assess the feasibility of renewable and alternative energy opportunities**	The feasibility of implementing renewable and alternative energy technologies shall be assessed at the design stage. For example, this must include the use of: • ground source heat pumps and combined heat and power (CHP) • use of local water sources for reduced condensing conditions • wind and solar power where appropriate • electricity from suppliers of 100% renewable electricity • heat reclamation opportunities. Further information on renewable and alternative energy technologies is provided in the Carbon Trust's Renewable Energy Sources Technology Overview (CTV010).
3.1.7	**Remanufactured items**	Use of remanufactured items that are still of an energy efficient nature shall be specified as standard. Obsolete equipment with low comparative energy performance shall be scrapped.

No	Name	Description
3.1.8	**Measurement/ benchmarking**	At the design stage, TEWI/energy usage calculations shall be carried out and benchmarked across a range of store groups/locations, etc. Non-conforming stores must be analysed to ensure that the design is of an appropriate standard. Further information on TEWI is provided in the BRA document 'Guideline methods of calculating TEWI'. Considerations should include energy used in lighting, heating and cooling in a W/m^2 format; and a W/m of installed cabinets for chill and frozen, with W/m^3 separately for cold-rooms and freezers.
3.1.9	**Sub-metering**	All aspects of sub-metering shall be discussed between clients and retailers at the design stage. A system shall be put in place to allow the collection and analysis of the sub metering data, and to provide a route for acting on the basis of those data. Logging and remote access to sub-meter data (inside and outside store) are essential. Sub-metering should include compressor pack, condenser, and cabinet groups and distribution boards.
3.1.10	**Building controls**	The total built environment requires control systems that respect the requirements of the refrigeration sales floor (for example, supply air distribution over cabinets with an open design style). Installers shall ensure that data-sharing capability is in place between the building management system (BMS), and refrigeration controls and monitoring systems. However, one system must not be able to alter the settings of another. All control systems installed shall be capable of providing adequate data collection (for example, power monitoring, and building and ambient temperature and humidity) to ensure that the system performance can be monitored and evaluated to maintain optimum efficiency. An annual review of performance data shall be carried out. The BMS shall be able to identify all cooling and heating systems, and any conflict between systems. Any conflicts that can be resolved shall be. The design shall eliminate the requirement for manual override of the plant and equipment. Where this is not possible, control systems shall be 'locked down'. Any automated alarm that can be fitted shall be. All lighting shall have automatic control.

No	Name	Description
3.1.11	**System controls**	Good quality and effective control systems shall be installed to cabinets and plant. All information shall be fed back to a front-end system that can be remotely accessed and analysed. All control systems shall be future-proofed and capable of being upgraded.
3.1.12	**Data accessibility**	Remote monitoring with reporting back to a facilities management system shall be incorporated in the design. This shall report data such as inside and outside ambient temperature and humidity. Data cabling and speed (network) shall be suitable for the number of controllers on each network to ensure the polling latency does not exceed the network capacity. This must be in line with the manufacturer's specification. Systems shall be capable of presenting easily used data in a format that gives a breakdown of information to a resolution detail that is useful for technical evaluation.
3.1.13	**Location of plant in the store**	Plant location shall be considered in conjunction with the total load requirements, number of packs required, structural implications, building location and orientation, and future service and maintenance requirements. This must be at the forefront of any new store/retro fit discussion to achieve best practice energy efficiency and reduced refrigerant charge. Localised siting of refrigeration packs to the sales floor loads will reduce capital cost on pipework and reduce energy usage. Siting of the refrigeration plant locally to the condensing medium will give similarly beneficial effects.
3.1.14	**Common design specification**	A clear design or specification manual shall be available for each scheme to enable consistent equipment selection and operation. This should be developed by the customer or their representative and must specify the required equipment standard (for example, equipment sizing (single system pump, or a run and standby)), maximum load conditions and energy efficiency. Updates of the specification manual should be carried out at no less than six monthly intervals or at every instance of change control. Cross fertilisation of information between retailers on like equipment should take place through participation in forums such as the BRA and/or IOR. Any high-level directional air discharge shall be designed in such a way so as not to affect cabinet air flows.

No	Name	Description
3.1.15	**Purchasing and tender review**	Multiple tenders shall be requested. Tenderers shall be asked to provide ratings against specific metrics, such as power consumption, and tender analysis shall ensure compliance with the technical specification prior to cost evaluation taking place. System design shall be evaluated in accordance with BRE Environmental Assessment Method (BREEAM) or an equivalent assessment methodology. At the design stage, appropriate stages of installation must be identified for quality assurance checks against the tender document and specifications. These may include pipework installation, pressure testing and evacuation, commissioning, handover and benchmarking. The quality assurance checks specified must include intrusive inspections and non destructive testing to ensure that the relevant standards of workmanship are achieved. Full details of expected quality assurance checks must be provided to the installation team. The design team shall provide the installer with a full design 'bill of materials', and materials and components specification/selection, coordinated with isometric drawings. The designer shall define the planned preventive maintenance schedule in line with any original recommendations from the equipment manufacturer. This shall include performance analysis.
3.1.16	**Audit and recalibration**	A full system audit shall be completed remotely twice a year by a competent control engineer or commissioning engineer. Energy audits shall be performed continuously on line, with alarms raised when specified parameters exceed pre-defined limits. If remote access is limited, then site systems audit shall take place at least once a year by a competent commissioning engineer.
3.1.17	**Post-installation evaluation**	Estimated running costs at the design stage shall be compared with actual post-installation running costs. Any deviations should be identified and appropriate action taken, including the incorporation of lessons learned into future design calculations.
3.1.18	**Feedback process (installed system to designer)**	Design staff shall communicate regularly with service and maintenance organisations, and should take account of feedback from previous systems during the design process.

3.2 Installation

Best practice in building services installation ensures that systems are installed in a way that is consistent with low carbon design. The installation team will have responsibility for the following best practice areas.

No	Name	Description
3.2.1	**Policy on installation**	Buildings and the systems within shall be installed in line with a robust policy of minimising carbon emissions throughout their lifetime. The principles of this policy shall include minimisation of carbon emissions, refrigerant leakage and embodied carbon, as well as measuring and benchmarking performance, minimising waste, understanding the cost of carbon, and proactively and continuously improving plant performance.
3.2.2	**Staff skills and knowledge**	All construction operatives (building, HVAC, electrical and refrigeration) shall be qualified and competent, and able to demonstrate that all work is carried out in line with best practice and in accordance with the guidelines laid down in these procedures. The main building contractor shall provide all staff with an understanding of the importance of reducing carbon emissions and energy use through better building design. For further information, refer to the Training and Skills section in the Code.
3.2.3	**Time planning**	Appropriate time shall be allowed for system installation, including that for testing. This will reduce the risk of having to pressure test a system for a second time.
3.2.4	**Alignment with design specification**	From the outset of any installation, all designs and isometric drawings shall be accurately adhered to. Installation shall be checked, against design, by the client or their representative. The installation team must check that the building installation meets the design specification. If it becomes necessary to reroute any refrigeration services during an installation, this should only be carried out with prior approval from the relevant designer, and after a full redesign and reissuing of the relevant isometric drawings has been completed. Documentation shall be created to show due diligence and compliance with test procedures relevant to the installation (for example, pressure testing, leak testing, and validation to specification). This shall include testing and inspection witnessing.
3.2.5	**Installation materials**	Good-quality material shall always be used. All products must be clearly marked for identification and traceable under all relevant Directives, such as the Pressure Equipment Directive (97/23/EC).

No	Name	Description
3.2.6	**Operation and maintenance manual**	An operation and maintenance manual shall be created that contains 'as installed' drawings, covering all layout and technical aspects of the completed installation. It must also include an installation bill of components. Installation documentation 'as witnessed' shall be signed by the responsible designer and included in the operating manual. All legal documentation with required service specifications and frequency (for example, Pressure Equipment Directive inspections and F-Gas logs), shall be included in the operation and maintenance manual.
3.2.7	**Interaction with other systems**	Any heat recovery from refrigeration equipment shall be clearly defined and the equipment to be served identified. When installing heat recovery and other connected systems, installers must ensure co-ordination with mechanical and electrical consultants to ensure a system's compatibility in the building. Installation of systems in conjunction with heat recovery shall differentiate between different grades of heat required (for example, space heating and hot water) to ensure optimum efficiency of the refrigeration plant, while providing heat recovery.
3.2.8	**Audit**	The client or their representative shall audit the installation for compliance with the specification throughout the installation period.
3.2.9	**Review**	A post-installation review of commissioning shall be carried out at intervals of three months for the first 12 months of operation. Following this, annual reviews shall be carried out by remote monitoring.
3.2.10	**Feedback process (installed system to designer)**	Design staff shall communicate regularly with service and maintenance organisations, and must take account of the feedback from live system's performance during the design process for future schemes.

3.3 Commissioning

The commissioning process is essential to ensuring that all systems installed operate as efficiently as possible and with a minimum number of conflicts with other building services. The commissioning team will have responsibility for the following best practice areas.

No	Name	Description
3.3.1	**Policy on commissioning**	Buildings and the systems within shall be commissioned in line with a robust policy of minimising carbon emissions throughout their lifetime. The principles of this policy shall include minimisation of carbon emissions, refrigerant leakage and embodied carbon, as well as measuring and benchmarking performance, minimising waste, understanding the cost of carbon, and proactively and continuously improving plant performance.
3.3.2	**Staff skills and knowledge**	The main building contractor shall provide all staff with an understanding of the importance of reducing carbon emissions and energy use through better building design. For further information, refer to the Training and Skills section in the Code.
3.3.3	**Time planning**	Appropriate time shall be allowed for system installation, including sufficient time for testing. This will reduce the risk of having to pressure test a system for a second time.
3.3.4	**Documentation**	Commissioning staff shall provide certificate documentation to demonstrate proof of operation and show comparison to design.
3.3.5	**Commissioning audit**	The client or their representative shall witness/audit the pressure test process and performance test.
3.3.6	**Commissioning test procedures**	Each retailer shall include in their refrigeration specification full commissioning details of their bespoke cabinets and plant. All legislative requirements for pressure testing under the Pressure Equipment Directive (97/23/EC), shall be strictly complied with. This must include HVAC, cabinets, cold rooms and the building envelope. Ancillary equipment (for example, controls, front ends, leak detection) shall be commissioned to the original equipment manufacturers requirements and, where possible, included in the specification All commissioning set points shall be recorded by the commissioning engineer and checked against the design specification. They shall be saved on site as a hard copy. Formal off-site electronic storage shall also be in place via an extranet site.

No	Name	Description
3.3.7	**Heat recovery (and other related equipment)**	Commissioning of heat recovery and other connected equipment shall be conducted in conjunction with mechanical and electrical full-system verification, and operation shall be conducted to confirm operation to design requirements. Heat recovery shall be stopped when it becomes uneconomical compared with obtaining the heat by other means.
3.3.8	**Control systems**	Control system commissioning shall verify operation against design and all readings must be recorded. Remote access shall be confirmed. All commissioning set points must be as stated in the design specifications. Where site specific commissioned values (for example, defrost settings) are required, these shall be documented.
3.3.9	**Building controls**	Commissioning the control system of building management systems shall verify operation against design and all readings must be recorded. Remote access shall be confirmed. All commissioning set points shall be as stated in the specifications. Where site-specific commissioned values (for example, defrost settings) are required, these must be documented and approved by the designer.
3.3.10	**Power monitoring systems**	Commissioning power monitoring and sub-metering systems shall verify operation against design and all readings must be recorded. Remote access shall be confirmed. All commissioning set points shall be as stated in the specifications. Where site-specific commissioned values are required, these must be documented and approved by the designer.
3.3.11	**Baseline of building performance**	The delivered building performance shall be compared with the design requirements and against other installations in the same peer group. All commissioning set points shall be as stated in the specifications. Where site-specific commissioned values (for example, defrost settings) are required, these shall be documented and approved by the designer.
3.3.12	**Audit and validation**	A commissioning audit must be carried out annually, where system performance should be compared against the design specification and benchmarked for future reference. All installations shall be remotely interrogated by a competent control engineer or commissioning engineer after initial site commissioning. This shall be incorporated into a proving period where the site is assessed weekly, against the design specification, over a 4-week period with very specific pass/fail criteria for parameters such as temperature, pressure and energy consumption. Recommendations for future audit/re-calibration works shall be incorporated into specifications and/or operation and maintenance manuals, and issued to the operating contractors. Following satisfactory completion of the audit, a commissioning certificate shall be provided to the end user.

No	Name	Description
3.3.13	**Retune after commissioning**	If an operational proving period is incorporated, then post-installation PPM shall be established as indicated above. If no proving period is undertaken, then the system operational settings shall be revisited four times in the first year prior to incorporation of the PPMs and annually thereafter. This shall be undertaken through a visit by the commissioning engineer.
3.3.14	**Recommissioning**	Handover procedures shall be incorporated in the retailer's specification. Where no operational proving periods are available, formal handover shall include verification of all commissioning and systems run, and integrity confirmations by the end user or their representative.
3.3.15	**Feedback process**	Feedback from the commissioning process shall be provided to the design, installation and end-user teams to allow lessons learned to be incorporated into ongoing and future projects.

3.4 Operation

Best practice operation of refrigeration systems ensures that equipment is operating as efficiently as possible, that any maintenance issues are addressed in a timely fashion and that there is a minimum level of conflict with other systems operating in the building. The operations team will have responsibility for the following best practice areas.

No	Name	Description
3.4.1	**Policy on operation**	Buildings and the systems within shall be operated in line with a robust policy of minimising carbon emissions throughout their lifetime. The principles of this policy shall include minimisation of carbon emissions, refrigerant leakage and embodied carbon, as well as measuring and benchmarking performance, minimising waste, understanding the cost of carbon, and proactively and continuously improving plant performance.
3.4.2	**Staff skills and knowledge**	Store management and key store staff (that is, energy or carbon champion) shall be aware of the key environmental aspects associated with store performance. All maintenance and operational staff shall have an understanding of the importance of reducing carbon emissions and energy use through better building design. For further information refer, to the Training and Skills section in the Code.
3.4.3	**Data logging**	Details of plant operation (for example, suction discharge pressure, store and ambient temperature, maintenance issues) shall be recorded in an electronic logging system. Data logging systems shall have a suitable data extraction rate for the task required. This shall be adjustable (that is, from 5 seconds to 15 minutes) and the data extraction rate used shall be aligned with the designer's recommendations. All parties concerned (for example, end user, service contractor, manufacturer) must be able to access relevant data concerning the operation of the refrigeration system in a timely manner to assist with identifying improvements or diagnosis of problems. These data shall be remotely accessible.
3.4.4	**PPM**	Time and access shall be allowed for all required parties to conduct PPM in line with the operation manual provided by the design team. PPM tasks must be completed to ensure efficient performance of the plant in line with its design. This will also reduce the potential for catastrophic failures to the system, which could result in damage, large release of charge and disruption in trading. Equipment and pipework shall be visually inspected for damage and malfunction on a daily basis. The operator shall make a record of the inspection. For further information, visit www.realzero.org.uk

No	Name	Description
3.4.5	**Heat recovery**	Heat recovery systems shall be checked annually to ensure optimum operation. Heat recovery systems that are not functioning properly can increase store energy use for no useful gain. Heat recovery systems that are not functioning correctly shall be adjusted/repaired to reduce energy consumption and CO_2 emissions.
3.4.6	**Control systems**	Control systems must be operationally locked down after commissioning, and only altered during operation by trained and authorised personnel. Building controls shall always be set so as to maintain the maximum possible efficiency of any systems in operation. Operators carrying out adjustments to building controls must consider the impact of the adjustment on refrigeration and other systems before alteration. Where adjustments need to be made (for example, for maintenance purposes), settings shall be re-aligned with the original commissioning specification immediately afterwards. Store controls and equipment shall not unduly conflict with each other.
3.4.7	**Power monitoring systems**	Power monitoring systems shall be checked daily to ensure correct function. Large deviations in power usage shall be addressed by the operator - the cause must be identified and rectified (this may be through escalation to the service and maintenance team).
3.4.8	**Baseline building performance**	Following commissioning, a baseline of building systems' performance shall be collated. Deviations from this baseline during operation shall be investigated as part of ongoing service and maintenance, and building performance brought back into line with the baseline.
3.4.9	**Benchmarking**	System performance, energy use and carbon emissions shall be benchmarked on an annual basis and compared against the existing stock and new benchmark model.
3.4.10	**Feedback process (installed system to designer)**	Design staff shall communicate regularly with service and maintenance organisations, and should take account of feedback from live systems during the design process of future projects.

3.5 Service and maintenance

Service and maintenance is key to addressing issues that may reduce the efficiency of system operation and lead to higher carbon emissions. Service and maintenance staff will have responsibility for the following best practice areas.

No	Name	Description
3.5.1	**Policy on service and maintenance**	Buildings and the systems within shall be installed in line with a robust policy of minimising carbon emissions throughout their lifetime. The principles of this policy shall include minimisation of carbon emissions, refrigerant leakage and embodied carbon, as well as measuring and benchmarking performance, minimising waste, understanding the cost of carbon, and proactively and continuously improving plant performance.
3.5.2	**Staff skills and knowledge**	All construction operatives (building, HVAC, electrical and refrigeration) shall be qualified and competent, able to demonstrate that all work is carried out in line with best practice and in accordance with the guidelines laid down in these procedures. The main building contractor shall provide all staff with an understanding of the importance of reducing carbon emissions and energy use through better building design. Service and maintenance staff shall be familiar with CIBSE Guide F. For further information, refer to the Training and Skills section in the Code.
3.5.3	**Remote analysis and management diagnostic**	The system shall be equipped with robust transducers and probes to feed data to a remote monitoring station. Equipment performance data shall be benchmarked by the service and maintenance engineer. These data should be made available at the monitoring station and should include: • power consumption • suction pressures • cabinet temperature.
3.5.4	**System interrogation**	Service and maintenance staff shall be familiar with a range of devices available to interrogate the system, including local systems, PDAs, handheld controllers and front-end panels.
3.5.5	**Logging changes**	Systems with configurable temperature data collection shall have enough data storage space to hold at least 18 months worth of data. Service and maintenance actions shall be recorded electronically and as a hard copy. This shall include any changes to system settings.
3.5.6	**Power monitoring systems and benchmarks for store and sub-metering**	Energy and ambient temperature data from pilot stores shall be used as a benchmark for monitoring refrigeration system operation. Significant deviations shall be investigated by the service and maintenance engineer.

No	Name	Description
3.5.7	**PPM**	Original equipment manufacturers' recommendations for service and maintenance shall be followed. Standard PPM for local conditions, environment and trading shall be adopted. Standard PPM actions shall be made available to, and followed by, all service and maintenance staff. The PPM calendar shall be linked to remote and local panels. System analysis shall be carried out before and after PPM activity. This shall be undertaken locally and remotely. PPM activity shall be audited by the remote monitoring team before and after the PPM visit to verify correct system operation.
3.5.8	**Controls**	Open protocols shall be used to enable integration with a variety of systems and manufacturers. Telemetry of changes shall be in place. Following service and maintenance, confirmation shall be sent to remote monitoring that work is complete and this must authorise the system to revert to authorised set points (this might take place following the completion of PPM).
3.5.9	**Data accessibility**	Service and maintenance records shall be kept in a recognised format that is easily accessible (for example, a spreadsheet). Key monitoring parameters shall all be available through one access point. Remote and local access to monitoring parameters shall be available, and service and maintenance staff must be familiar with their location and the latest figures.
3.5.10	**Audit and recalibration**	Service and maintenance engineers shall refer to equipment manufacturers for details of optimum system recalibration intervals. Service and maintenance engineers shall use maintenance data to help determine optimum audit intervals. Remote interrogation to review settings/calibration and trigger when intervention is required shall be undertaken (for example, prolonged and unexpected system pressure, temperature, suction and discharge). Service and maintenance engineers shall use known data readings to check the calibration of the system.
3.5.11	**Feedback process (installed system to designer)**	Design staff shall communicate regularly with service and maintenance organisations, and should take account of feedback from live systems during the design process for future systems.

4. Testing and inspection

Working group introduction

Background

This section of the Code contains best practice information related to testing and inspection activities in the retail refrigeration sector. It provides guidance on ensuring that refrigeration systems are efficient and low carbon in nature, from the initial design stage through to the day-to-day operating procedures, and service and maintenance activities.

The working group was challenged with collating best practice testing and inspection advice that could be applied across the different life-cycle phases of a refrigeration system, by professionals ranging from design engineers to store refrigeration managers. As a result, this working group contains representatives from a range of practices including end users, installation and maintenance contractors, manufacturers and training organisations. The testing and inspection working group consists of 11 members. A full list of members is provided in the Appendix.

Scope

This working group focuses on best practice in testing and inspection activities across the practices of design, installation, commissioning, operation, and service and maintenance.

Aims and objectives

The overall objective of this working group was to produce a defined set of best practices that articulates the most appropriate activities necessary to deliver safe, energy-efficient and lowest carbon outcomes through effective testing and inspection routines.

Specifically, this includes the following aims:

- to ensure consistency and quality in testing and inspection activities
- to improve the quality of testing and inspection procedures and reduce the direct carbon emissions associated with these practices, and those that are indirectly associated, but can be influenced by testing and inspection
- to improve engagement and communication on testing and inspection requirements between the parties involved in the design, installation and operation phases of retail refrigeration systems.

Target audience

The testing and inspection best practices are designed to be used by those involved across all phases of the life cycle of the retail refrigeration systems from design to operation and service and maintenance.

This includes the design and installation of energy efficient, low carbon systems that can be tested and inspected throughout their life to ensure that they are operating at their design or optimum performance. From commissioning onwards, the best practices can be used to ensure that any drop in performance can be identified quickly and addressed by the end user or their contractor for reference or direct action.

Best practices

4.1 Design

Test and inspection can only be carried out effectively if the procedures and processes involved are incorporated into the design of a refrigeration system. Therefore, it is essential that designers take the following into consideration.

No	Name	Description
4.1.1	**Policy on design**	Contractors shall have a clear policy on how they manage test and inspection in their design process. Such a process shall be consistent with ISO 9001:2008. The test and inspection policy documents shall clearly define: • there is zero tolerance to refrigerant leakage • what the expected energy usage will be • what the expectations are for uptime of equipment and systems, safety, and levels of maintenance and breakdowns • methods by which these shall be quantified.
4.1.2	**Documentation**	The designer shall define the tests and frequency of inspection that shall be carried out during installation, commissioning and operation. The testing and inspection design parameters for commissioning shall be defined and must meet the requirements of the Pressure Equipment Directive. These shall be contained in and the installation and commissioning documents and the operation and maintenance manual. The operation and maintenance manual shall provide checklists for inspection of individual items for maintenance and possible faults. The designer shall identify and document any risks that should be taken into account during testing and inspection that could not be eliminated as part of the initial design. An independent inspection of the installation documentation supplied by the designer shall be carried out. This should be reviewed to ensure efficient services routes are taken to reduce pressure drops and unnecessary rises, and to ensure free-and-easy access is provided for maintenance.
4.1.3	**Test and inspection process**	The designer shall: • define the inspection process that shall be adhered to during installation and commissioning, which shall align with BS EN 378:2008 (Refrigerating systems and heat pumps) and the Pressure Equipment Directive (97/23/EC) • ensure that the design enables the inspection process and any future maintenance to be carried out effectively, efficiently and safely; that sufficient space is available for operatives to access the system; components can be isolated and removed with minimal disruption; and spare components are readily available

No	Name	Description
4.1.3	**Test and inspection process**	• ensure that the design simplifies the inspection process and minimises inspection time by ensuring that the refrigeration system is designed to contain refrigerant • specify that sufficient measurement points and data logging equipment are incorporated into the design to enable fault finding during inspection (for example, this may include sub-metering power points, sufficient pressure testing points and temperature sensing points (in line with food hygiene requirements)). Further information and guidance on these issues is provided in the IOR/BRA Guides to Good Commercial Refrigeration Practice (Parts 1-9) and by REALZero.
4.1.4	**Validation and audit**	End users shall have a policy for validating and auditing the design process. This shall be consistent with ISO 9001:2008. On completion of an installation, the designer shall receive feedback from the installing, commissioning and service/maintenance engineers on how better to design the equipment for future installations.

4.2 Installation

Testing and inspection is a vital part of the installation process to ensure zero refrigerant leakage and system safety and performance. The following should be taken into account during installation.

No	Name	Description
4.2.1	**Policy on installation**	Installers shall have a clear policy on how they manage the installation process. Such a process should be consistent with ISO 9001:2008. The installation policy documents shall clearly define that there is zero tolerance to refrigerant leakage; what the expected energy usage will be; what expectations of uptime and availability of equipment and systems, safety, levels of maintenance and breakdowns will be; and the methods by which these shall be quantified in the testing and inspection process.
4.2.2	**Documentation**	The installer shall: • document any deviations from the designer's test and inspection installation document and the reasons for variations • ensure that all test certificates for equipment are included in the operation and maintenance manual • ensure that all equipment is delivered with a copy of the relevant certificates: - CE marking certificate (where required) - Electrical certificate – National Inspection Council for Electrical Installation Contracting - Pressure Equipment Directive certification (for equipment that is part of a pressure system – either a pressure vessel or pipework) - Gauge calibration certificates - Declaration of conformity. Further information on documentation can be obtained from REALZero.

No	Name	Description
4.2.3	**Test and inspection process**	The installer shall provide written confirmation of employee qualifications (for example brazing qualifications, Skill card, F-Gas, NVQ, City and Guilds, ConstructionSkills) to the principal contractor before starting work on site. The commissioning specialist shall have approved the provision of test points for pressure testing and evacuation of the system before installation commences. The installer shall: • ensure that any temporary inspection points are removed and a permanent joint installed • ensure that sufficient permanent inspection points and valves are provided in accessible positions to enable future testing and maintenance of the system • ensure that sub-assemblies (for example, compressor packs, display cabinets) that have been factory strength-and-tightness tested shall be delivered with a holding charge of oxygen-free, dry nitrogen • confirm and record that the holding charge is intact, or shall retest the sub-assembly (if the holding charge has been lost), to ensure that it is leak-tight before connecting to the system • the end user's representative has confirmed that the installation has been installed in accordance with the project requirements.
4.2.4	**Validation and audit**	The designer, installation contractor and end user shall have a policy for validating and auditing the installation process. On completion of an installation, the installer shall feed back information to the designer on how to improve the design of equipment for future installations.

4.3 Commissioning

Testing and inspection is an integral part of commissioning and sufficient time should be allowed to make sure that the operation of all equipment is checked and inspected. The following should be taken into account during commissioning.

No	Name	Description
4.3.1	**Policy on commissioning**	Commissioning engineers shall have a clear policy on how they manage the commissioning process. Such a process should be consistent with ISO 9001:2008, and should draw upon the design criteria. The commissioning policy documents shall clearly define that there is zero tolerance to refrigerant leakage; what the expected energy usage will be; what expectations of uptime and availability of equipment and systems, safety, levels of maintenance and breakdowns will be; and the methods by which these shall be quantified in the testing and inspection process. Commissioning policy should allow: • sufficient time in the commissioning plan for setting to work AND design verification. If the start of commissioning is delayed due to the delayed completion of earlier activities, then the completion shall also be delayed where possible. If completion cannot be delayed then sufficient time and access to site shall be provided after completion for the design verification to be done • sets of operating parameters to be completed under a variety of load and ambient conditions. This may require a return visit to site several months after handover to complete the tests. The operation and maintenance manual should highlight inspection frequency and should include at least a revalidation of the design 6 months after initial commissioning.
4.3.2	**First Pressure Systems Safety Regulations inspection**	Documentation: • The end user shall provide a written scheme of examination for the plant. • The results of the inspection shall be copied to the site log book. Requirements for site log books are set out in BS EN378-4: 2008 (Refrigerating systems and heat pumps). Test and inspection process: • The plant shall be inspected according to the written scheme of examination before it is put into service and handed over to the operator. • This first inspection shall form the baseline for the future inspections of the system and also acts as a check that the written scheme is suitable for the system.
4.3.3	**Commissioning equipment**	Documentation: • The calibration certificates shall be provided by the installer before the start of commissioning and held on site for review until completion. This should form part of the operation and maintenance manual. Test and inspection process: • The pressure gauges, temperature probes, electrical meters and other commissioning measurement devices shall have valid calibration certificates and be calibrated to the accuracy that the equipment manufacturer recommends. Using calibrated pressure gauges is essential to ensure safety during the strength pressure test.

No	Name	Description
4.3.4	**Pressure and evacuation**	Documentation: • A written procedure for strength pressure and tightness testing, and the subsequent vacuum of the plant shall be provided to the commissioning engineer by the designer. The written procedure shall be in line with BS EN 378:2008 (Refrigerating systems and heat pumps) and shall include a method statement and risk assessment for the pressure testing activity, including witnessing by a third party. Test and inspection process: • Before operation, the system must pass a strength pressure test, followed by a tightness test. The strength pressure test is conducted at a minimum pressure of 10% above the allowable system pressure. It is normal to use oxygen-free, dry nitrogen for the strength pressure test. • The tightness test should also be conducted with oxygen-free, dry nitrogen and can be combined with the strength pressure test if appropriate. It is essential to check to ensure that the system is leak-free before refrigerant is charged. This is a key element in ensuring that refrigerant loss to atmosphere is minimised. • After the tightness test is complete, the nitrogen shall be released to atmosphere. This shall be done in a safe and controlled manner. Following this, a triple evacuation process should be carried out. Further information can be found in the REALZero 'Guide to Good Leak Testing' and 'Illustrated Guide to 13 Common Leaks'.
4.3.5	**Operation and maintenance manual/log book**	Documentation: • It should be noted that inspection against a written scheme is a legal safety requirement. • Commissioning results shall be recorded in the site log book, which shall be part of the operation and maintenance manual. • Copies of the test results from the operating tests and legally required tests (Pressure Systems Safety Regulations, F-Gas) shall be filed in the site log book. • A register of F-Gas refrigerant charge shall be created and the first records entered. • Other plant certification (for example, electrical panel certificates, earth leakage test certificates) shall be collated. • Certificate from the designer and commissioning engineer confirming that the installation met their expectations in performance at the end of the commissioning period. • A written service and maintenance scheme shall be in place prior to handover of the system to the operator. This shall state the system components, method and frequency of inspection, and maintenance required during the system life.

No	Name	Description
4.3.5	**Operation and maintenance manual/log book**	Test and inspection process: • Each major item of plant shall be checked in operation to confirm that it is performing as required. • Cabinets shall be checked for correct installation. This includes: - checking that LCD read outs can be easily read - ensuring that sensors are of the correct type and are in the correct location - ensuring that condensate drains are free flowing and leak free. • The sequence of operation provided in the operation and maintenance manual shall be performed to confirm that it is feasible. Any improvements in the sequence or errors and omissions shall be highlighted to ensure that the manual is corrected. These variations should be fed back to the designer. If any changes are made following recommendations by the commissioning engineer, then the commissioning should be rechecked. • Where possible, the sequence check shall be done in conjunction with the operator or maintenance contractor to ensure that they are familiar with the plant operation. Commissioning settings shall be held in the operation and maintenance manual for reference. Ideally, parameter settings should be locked to enable original settings to be maintained.
4.3.6	**Vibration/ movement**	Documentation: • The commissioning manual shall include an assessment of vibration and shall be compiled by the commissioning engineer, and included within the operation and maintenance manual. Test and inspection process: • The compressors and pipework shall be checked for undue vibration under a range of operating conditions during the commissioning process. • Where pipework is found to be moving excessively, the brackets shall be adjusted to provide adequate support. • The purpose of this check is to reduce stresses on the pipes that might lead to a component failure and major refrigerant leak at a later date.
4.3.7	**Validation and audit**	The end user shall have a policy for validating and auditing the commissioning process. This shall include: • a set of commissioning sheets to be filled in with performance data and provided by the system detailing compressor, condenser and evaporator performance, and control sequence data • completing and returning the commissioning sheets to the designer in good time to enable them to be checked • investigating and correcting any discrepancy between expected and actual values • the validated design forming the basis of record sheets for future performance checks.

4.4 Operation

Operators are part of the overall maintenance process and shall carry out routine checks on equipment.

No	Name	Description
4.4.1	**Policy on operation**	End users shall have a clear policy on how they manage plant operation. Such a process shall be consistent with ISO 9001:2008. The operation policy documents shall clearly define that there is zero tolerance to refrigerant leakage; what the expected energy usage will be; what expectations of uptime and availability of equipment and systems, safety, levels of maintenance and breakdowns will be; and the methods by which these shall be quantified in the testing and inspection process.
4.4.2	**Documentation**	A hard copy of the operation and maintenance manual compiled by the designer and verified by the installer shall be available for inspection and held on site. An electronic copy shall be held by the end user to enable future updates to be applied.
4.4.3	**Test and inspection process**	Ad-hoc visual checks: • End-user staff shall be given awareness training, as part of their staff induction, to recognise and report issues. Typical examples include high equipment temperature, slow recovery after defrost, unusual noises and water on the floor. Further information and support can be obtained from REALZero and F Gas Support. • Planned maintenance inspection visits shall be scheduled annually, with clear access to carry out work. • End-user staff shall inspect (monthly) and carry out ongoing cleaning of cold store areas as required. Planned maintenance and testing: • Shall be carried out in line with the operation and maintenance manual, and the service and maintenance company's ISO 9001:2008 procedures. • Leak testing shall form part of the equipments planned maintenance on a monthly cycle. Further information can be found in the REALZero 'Guide to Good Leak Testing' and 'Illustrated Guide to 13 Common Leaks'. • Electrical testing shall be carried every 12 months in accordance with electrical standards. • Monitoring of refrigerated display and storage cabinets shall be carried out at least twice daily. Automatic electronic monitoring should be employed continually and should have the capability to provide a historical record of performance, coupled with an automatic alarm system. Data to be monitored include temperature, defrosts carried out, humidity and power monitoring.
4.4.4	**Validation and audit**	The end user shall have a policy for validating and auditing the operation of the plant. The end user shall feed back information to the designer on how to improve the design of equipment for future installations.

4.5 Service and maintenance

It is essential to maintain and service equipment to maintain performance. Therefore, testing and inspection is an essential part of any service and maintenance contract, and should take into account the following.

No	Name	Description
4.5.1	**Policy on service and maintenance**	Service and maintenance companies shall have a clear policy on how they manage plant operation. Such a process shall be consistent with ISO 9001:2008. The service and maintenance policy documents shall clearly define that there is zero tolerance to refrigerant leakage; what the expected energy usage will be; what expectations of uptime and availability of equipment and systems, safety, levels of maintenance and breakdowns will be; and the methods by which these shall be quantified in the testing and inspection process.
4.5.2	**Documentation**	The operation and maintenance manual shall be maintained by: • ensuring commissioning data and all settings are entered in the relevant sections • checking current settings against commissioned ones and investigating discrepancies • correcting settings or reporting discrepancies to end users to update documentation/ master copy. When inspecting plant services, engineers shall maintain an electronic plant log by: • ensuring all entries are signed and dated • ensuring all plant and equipment faults are contained in the log • recording all events detailing alarm overrides, including justification for override • reviewing alarms before starting and after completing work, and notifying the supervisor/engineering manager if alarms occur repeatedly.
4.5.3	**Test and inspection process**	End users shall: • allow service engineers sufficient time and access to inspect systems during repairs and planned preventive maintenance visits. During service and maintenance visits, engineers shall routinely: • carry out a visual inspection of the installation • make repairs where necessary • advise the end users of any issues that will affect performance • ensure that the electronic communications system (local and remote) is operating correctly. Further information can be found in the REALZero 'Guide to Good Leak Testing' and 'Illustrated Guide to 13 Common Leaks'.
4.5.4	**Validation and audit**	Service and maintenance companies shall have a clear methodology for validating and auditing their performance. There shall be a process where service and maintenance companies will review their performance with the end user. This should provide a positive forum to discuss and improve performance indicators.

Appendix

During the development of the Code of Conduct, the following members took part in each working group.

Training and skills

John Austin-Davies – Epta Group/George Barker (Chair)

Nigel Armitage – Emerson

Paul Arrowsmith – WR Refrigeration

Bob Arthur – Marks and Spencer

Steve Benton – Cool Concerns

Keith Bertie – Emerson

John Fraser – STAR Refrigeration

Eddie Gittoes – British Refrigeration Association (BRA)

Kevin Mattimoe – Sainsbury's

Michael Reeves - SummitSkills

Miriam Rodway – Institute of Refrigeration

Containment

Brian Churchyard – ASDA (Chair)

Paul Arrowsmith - WR Refrigeration

James Bailey – BJA Consulting

John Bonner – City Refrigeration Holdings (UK) Ltd

David Cowan - Institute of Refrigeration

Keith Duncan – Honeywell

Jane Gartshore – Cool Concerns

Bob Hurley - Tesco

Barry Lyons – BOC

Miriam Rodway – Institute of Refrigeration

Buildings

Robert Arthur – Marks and Spencer (Chair)

Mike Coult – Oaksmere Design

Conor Eaton-Smith – Arctic Circle

Dean Frost – Space Engineering

Richard Guy – Carbon Trust

Guy Hodgins – Honeywell

Mark Hughes - Dupont

Bob Hurley - Tesco

Mike Lawrence - JTL

Nick Rivers – Ryan Jayberg

Testing and inspection

John Skelton – Sainsbury's (Chair)

Bob Arthur – Marks and Spencer

Richard Biffin – WR Refrigeration

Steve Gill – Energy Efficient Solutions

Les King – Waitrose

Luke Marriott – WR Refrigeration

David Paget – Lloyd's Register

Andy Pearson – Institute of Refrigeration

Nick Rivers – Ryan Jayberg

Bill Watson – The Co-operative Group Ltd

Adrian Westrup – Coldservice

The Carbon Trust is a not-for-profit company with the mission to accelerate the move to a low carbon economy. We provide specialist support to business and the public sector to help cut carbon emissions, save energy and commercialise low carbon technologies. By stimulating low carbon action we contribute to key UK goals of lower carbon emissions, the development of low carbon businesses, increased energy security and associated jobs.

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- leading industry collaborations to commercialise technologies
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