Foreword

This Code of Practice is prepared by the Institute of Refrigeration and has been ratified by its Technical Committee and Board of Trustees. The Code is provided free of charge to members for their exclusive personal or professional use. Non-members may purchase PDF copies from the IOR at www.ior.org.uk.

This Code is for the use and guidance of everyone concerned with vapour compression refrigerating systems that use Refrigerant R-717 (ammonia). Ammonia is a safety classification group B2L refrigerant. “Everyone” means every person with responsibility through ownership, consultancy, design, construction, installation, commissioning, operation, maintenance, inspection, repair, modification, decommissioning or testing of a system. Attention is drawn to wider responsibilities as defined in the Health & Safety at Work etc. Act 1974. In particular when a system has been altered or repaired the pressure envelope must be proved again by testing at least the altered or repaired sections together with any other parts of the system which cannot be isolated from them. Under the Pressure Systems Safety Regulations 2000 (PSSR) appropriate written schemes of examination and associated inspections must have been conducted and under Dangerous Substances and Explosive Atmospheres Regulations 2002 the various regulations associated with assessment of risk, reduction of risk, zoning, marking, instructing must be in place. The PSSR also imposes certain obligations on the ‘user’ of refrigerating equipment.

This Code is intended to complement and reinforce details in BS EN 378:2016 and other relevant standards as referred to in this Code or its Appendices. Nothing in this Code is intended to conflict with British, European or International Standards and where relevant standards already exist, their recommendations have been recognised and incorporated where appropriate.

IOR Publications

IOR publishes Safety Codes of Practice specific to the following refrigerant types:
- Non Flammable, Lower Toxicity Refrigerants (Group A1)
- Flammable Lower Toxicity Refrigerants (Group A2L, A2 and A3)
- Carbon Dioxide R744
- Ammonia R717

The IOR also produces regular Guidance Notes on the characteristics, design, installation, service and good practice use of all refrigerants. IOR policy is to promote the responsible use of refrigerants, for the public benefit. A responsible refrigerant use policy places a high emphasis on the elimination of leak sources, the efficiency of the overall system and the life cycle cost of ownership.

Interpretation and updates

Advice as to the intended meaning of this Code or any part of it shall be the responsibility of the Board of Trustees of the Institute of Refrigeration for the time being or of such person or persons as they shall nominate. The Institute of Refrigeration welcomes all comments and suggestions relating to this or other Codes of Practice so that future versions can be improved upon. The contents of the Code is reviewed from time to time by the IOR and, when necessary, revisions will be published.

2018
# Contents

Section 1 – Scope and Limitations ........................................................................................................ 4

Section 2 – Relevant Properties of Ammonia ...................................................................................... 6
2.1 Physical properties ..................................................................................................................... 6
2.2 Chemical Properties and Potential Hazards .................................................................................. 7

Section 3 – Design of Components ................................................................................................... 10
3.1 General........................................................................................................................................ 10
3.2 Component Design and Test Pressures ..................................................................................... 10
3.3 Compressors .................................................................................................................................. 13
3.4 Pressure Vessels and Heat Exchangers ...................................................................................... 14
3.5 Liquid Ammonia Pumps .............................................................................................................. 16
3.6 Ammonia Control Valves and Sensing Devices ......................................................................... 16

Section 4 – System Design and Installation ....................................................................................... 19
4.1 General........................................................................................................................................ 19
4.2 Material Selection ....................................................................................................................... 19
4.3 Steel Piping Systems .................................................................................................................. 19
4.4 Copper Pipework ....................................................................................................................... 22
4.5 Location and Arrangement of Piping ....................................................................................... 22
4.6 Arrangement of Isolating Valves ............................................................................................... 23
4.7 Instrumentation ........................................................................................................................ 23
4.8 Protection against Excess Pressure ............................................................................................ 24
4.9 Protection against Environmental Effects .................................................................................. 24
4.10 Notification to Local Authorities .............................................................................................. 24
4.11 Refrigerant Detection .............................................................................................................. 24
4.12 System Labelling ..................................................................................................................... 24
4.13 Allowable Refrigerant Charge .................................................................................................. 25
4.14 Protection for Indirect Circuits ................................................................................................ 25
4.15 Additional Requirements for Ammonia ..................................................................................... 25

Section 5 – System Testing ................................................................................................................ 26
5.1 General....................................................................................................................................... 26
5.2 Strength Test Procedure ............................................................................................................ 26
5.3 Tightness Test Procedure ........................................................................................................... 27
5.4 Test Certificates ........................................................................................................................ 27

Section 6 – Commissioning of New Installations ............................................................................. 29
6.1 General....................................................................................................................................... 29
6.2 Evacuation and Dehydration ..................................................................................................... 29
6.3 Charging ..................................................................................................................................... 30
6.4 Protection Devices .................................................................................................................... 30

Section 7 – Inspection and Maintenance .......................................................................................... 31
7.1 General....................................................................................................................................... 31
7.2 System Log .................................................................................................................................. 32
7.3 Routine Inspection ..................................................................................................................... 32
7.4 Major Inspection ......................................................................................................................... 36
7.5 Pressure System Examination .................................................................................................... 41

Section 8 - Documentation ................................................................................................................ 45
8.1 General....................................................................................................................................... 45
8.2 Risk Assessment ........................................................................................................................ 45
8.3 Health and Safety File ............................................................................................................... 45
8.4 Written Scheme of Examination and Records ........................................................................... 45
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>Commissioning Records</td>
<td>46</td>
</tr>
<tr>
<td>8.6</td>
<td>Refrigerant Inventory Record</td>
<td>46</td>
</tr>
<tr>
<td>8.7</td>
<td>Contingency Provisions</td>
<td>47</td>
</tr>
<tr>
<td>8.8</td>
<td>The System Register</td>
<td>47</td>
</tr>
<tr>
<td>8.9</td>
<td>System Log</td>
<td>48</td>
</tr>
<tr>
<td>8.10</td>
<td>Instruction Manuals</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>Section 9 - Decommissioning</td>
<td>50</td>
</tr>
<tr>
<td>9.1</td>
<td>General</td>
<td>50</td>
</tr>
<tr>
<td>9.2</td>
<td>Recovered Refrigerant</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>Section 10 – References, Standards and Legislation (all refrigerants)</td>
<td>52</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Definitions</td>
<td>57</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Maximum Allowable Pressure and Strength Test Procedure</td>
<td>60</td>
</tr>
<tr>
<td>Appendix C</td>
<td>Pneumatic Strength Pressure Test Procedure</td>
<td>62</td>
</tr>
<tr>
<td>Appendix D</td>
<td>Marking and Name Plate Data</td>
<td>64</td>
</tr>
<tr>
<td>Appendix E</td>
<td>Handling, Transport and Storage of Refrigerant Cylinders</td>
<td>66</td>
</tr>
<tr>
<td>Appendix F</td>
<td>Commissioning of New Installations</td>
<td>68</td>
</tr>
<tr>
<td>Appendix G</td>
<td>Machinery Rooms and Auxiliary Safety Equipment</td>
<td>75</td>
</tr>
<tr>
<td>Appendix H</td>
<td>Typical Schedule for Inspection and Maintenance</td>
<td>79</td>
</tr>
<tr>
<td>Appendix I</td>
<td>Sample Details for Register</td>
<td>81</td>
</tr>
<tr>
<td>Appendix J</td>
<td>Sample Compressor Operating Data and System Log</td>
<td>82</td>
</tr>
<tr>
<td>Appendix K</td>
<td>IOR Policy on Refrigerant Choice</td>
<td>83</td>
</tr>
<tr>
<td>Appendix L</td>
<td>Stress Corrosion Cracking</td>
<td>84</td>
</tr>
</tbody>
</table>
Section 1 - General

1.1 Scope

The object of this Code of Practice is to define minimum requirements for safety in the design, construction and installation, commissioning, inspection, maintenance and decommissioning of vapour compression refrigeration systems utilising Refrigerant R-717 ammonia. These are classified as Group B2 refrigerants in BS ISO 817:2014 Refrigerants Designation and safety classification, and defined in BS EN 378:2016 Refrigeration Systems and Heat Pumps-Environmental requirements.

The term ammonia as used throughout this Code refers to anhydrous ammonia (chemical formula NH₃, refrigerant number R717) in gaseous or liquefied form. It is not to be confused with a solution of ammonia in water, commonly known as ammonia liquor or aqueous ammonia.

This Code of Practice is intended to apply within the United Kingdom to systems where the motors driving the compressors have a total installed power of more than 25kW, including any standby compressors, although most provisions may well apply to smaller systems. It also applies to systems where the refrigerant is changed to ammonia and to re-installed systems. Any alteration or repair to systems within the scope of this Code shall also comply with its requirements.

All minimum pressures specified in this Code are related to design temperatures applicable to refrigerating systems installed in the United Kingdom. Some systems including those used as heat pumps may be subjected to appreciably higher pressures than the minima specified and must be designed accordingly.

The definitions given in Appendix A of this Code together with those in BS EN 378-1:2016 apply throughout this document.

Health and Safety legislation in the United Kingdom does not require the design and construction of refrigeration systems to conform to any specific national or international safety standard, nor do they have to meet the requirements of this Code of Practice. If the design can be demonstrated to provide an equivalent level of safety and is in accordance with relevant regulations and directives, then deviation from the standard or code is acceptable. However the terms of a supply contract for equipment may require conformity with a specification which in turn cites certain published standards or codes of practice, in which case non-conformance would constitute a breach of contract.

The Code is broadly based and for any particular system the user, seeking specialist advice where necessary, must consider whether any conditions of design, duty, application, particular machinery used or environment should require additions to or modifications of the requirements expressed in this document.

Maintenance concerned with checking and rectifying the effects of wear and tear so that functional efficiency is upheld should be carried out in accordance with the manufacturer’s instruction manual. Such maintenance is not specifically covered in this document, which is concerned with maintenance in so far as it promotes safety.

1.2 Limitations

Throughout this Code the words “shall” and “should” have been used as follows:
“shall”: where “shall” or “shall not” is used for a specified requirement, that requirement is intended to be mandatory.

“should”: where “should” or “should not” is used for a specified requirement, that requirement is not intended to be mandatory but is recommended good practice.

This Code of Practice refers principally to those parts of a refrigerating system that are permanently or intermittently in contact with the ammonia. For other components or elements forming part of the system reference should be made to relevant standards or codes covering the respective parts and/or their materials.

This Code of Practice is not intended to apply to:
- ammonia systems installed in vehicles, ships or aircraft
- ammonia manufacturing plants
- ammonia transportation pipelines and tankers
- ammonia absorption refrigerating systems
- ammonia bulk storage vessels, not part of a refrigerating system
- ammonia refrigerating systems installed on railway rolling stock, motor vehicles, ships or aircraft.

This Code of Practice does not apply to refrigerants in groups A1, A2L, A2 and A3 as defined in EN 378:2016. Specific requirements for systems using groups A1, A2L, A2 and A3 refrigerants and carbon dioxide refrigerant are covered in separate Codes of Practice also issued by the Institute of Refrigeration.
Section 2 – Relevant Properties of Ammonia

2.1 Physical properties

Ammonia gas is toxic and inhalation may be lethal.

Ammonia suppliers readily make information available on hazards, precautions and first aid. Everyone concerned with ammonia refrigerating systems shall cause the information to be displayed.

Those responsible for ammonia refrigerating systems should obtain a copy of BS EN 378:2016 and the relevant safety literature published by the ammonia supplier. This information may assist the user of ammonia refrigerating systems to understand their statutory requirements.

2.1.1 Moisture solubility

Ammonia dissolves in water liberating heat and forming a strongly alkaline solution.

2.1.2 Lubricants

Mineral and synthetic oils with low solubility are commonly used in ammonia systems. The choice of oil is usually determined by the compressor manufacturer. Unless specifically required for operational reasons, it is inadvisable to change the type and make of lubricating oil used as this may affect the stability of the O-rings and seals. Soluble lubricants are available and used in direct expansion systems.

Any lubricant selected should be able to flow at the lowest temperature that it will encounter.

Because ammonia and mineral oil are almost totally immiscible, any lubricant that enters the low side of a system tends to stay there as a layer of oil below the ammonia unless lubricant recovery devices are installed or oil is purged from the system.

To eliminate the risk in oil draining, consideration should be given, at the design stage to incorporate an integral oil recovery system that would collect oil and return oil to the oil separator or reservoir and this precludes the need for draining oil.

To reduce oil from entering evaporators frequently compressor discharge line oil separators are installed.

All outlets to atmosphere (oil drain connections) must be fitted with a pressure tight closure, for example a blank flange or screwed plug or cap.

A “dead man’s handle” and a hand operated stop valve shall be fitted to all oil drain connections.

Where it has been determined that oil draining is unavoidable, operator training and a safe method of works is required to minimise risk. A second person should always be in attendance when oil is drained.

Personal protection equipment shall be worn when purging oil and this should include at least chemical resistant gauntlet gloves, well-fitting goggles and a canister type respirator.

Access to eye wash solution should be available. For systems with an ammonia charge in excess of
1000 kg an emergency temperature controlled water drench shower should be available.

Oil should be drained into a suitable open metal container and then disposed of in accordance with the relevant waste handling regulations.

### 2.2 Chemical Properties and Potential Hazards

A risk assessment shall be carried out prior to commencing any work. The following items should be considered - note this list is not exhaustive and a site specific risk assessment should be carried out.

The boiling point of anhydrous ammonia at atmospheric pressure is −33°C. During operation or when at rest all parts of a charged ammonia refrigerating system may be at a pressure above atmospheric. The system components such as compressors, piping and vessels are designed to contain the ammonia at pressure. In normal operation the integrity of the system shall be maintained at all times. No attempt to break piping joints or to remove valves or components shall be made without having first ensured that the relevant parts of the system have been relieved of pressure and safely and effectively cleared of ammonia.

#### 2.2.1 Reactivity

Ammonia with trace water attacks copper, zinc, tin, cadmium and most of their alloys and also many rubbers and plastics. Explosive or unstable compounds can be formed by reactions with mercury, halogens, hypochlorites, oxides of nitrogen and some organic compounds.

#### 2.2.2 Thermal decomposition

Ammonia is flammable in air at concentrations of 16% to 27% by volume. Explosions can occur if flammable mixtures are ignited in confined spaces, although ignition is more difficult than for fuel gases.

#### 2.2.3 Inhalation

Because of the particularly pungent odour of ammonia, when servicing systems particular care must be taken to ensure that no inadvertent release of ammonia takes place in areas where other personnel are working so as to avoid risk or undue alarm.

Ammonia has a characteristic odour and can be detected by smell at low concentrations typically less than 10 parts per million by volume (ppm). It is not a cumulative poison. Some plant operators can become tolerant to about 100 ppm apparently without unpleasant effects but this level is above the threshold limit value for long-term exposure. The threshold limit value is 25 ppm and short-term exposure limit is 35 ppm at the time of publication. Limits should be in accordance with the latest edition of the Health and Safety Executive guidance note EH40 “Workplace Exposure Limits” (see Section 10 of this Code).

Short-term exposure to concentrations of about 200 ppm will cause irritation and discomfort of the mucous membrane and the eyes, but with no lasting consequences. Exposure to concentrations above 1500 ppm will damage or destroy body tissue whilst exposure to 2500ppm and above increases the risk of fatality. Liquid ammonia splashes on the skin can cause both chemical and frost burns. The severity of the burning will depend upon the amount of liquid involved. Even the smallest liquid splash in the eyes may result in permanent injury.
2.2.4 Direct contact

Should ammonia come into contact with the skin or eyes, evaporation will cause freezing of the skin or eye fluids and freeze burns may occur. Clothing saturated with ammonia will freeze to the skin. Goggles, rubber or PVC gloves and other suitable clothing shall be worn whenever there is a risk of exposure to ammonia.

2.2.5 Potential sources of refrigerant leakage

The refrigerating system contains ammonia in both liquid and gaseous states. It is possible under abnormal conditions for liquid ammonia to enter the compressor, for example by way of faulty valves or by overcharge of ammonia to the system. A compressor is designed to compress ammonia gas and not to pump liquid; if excess liquid does enter a compressor damage can occur, with possible release of ammonia. Liquid ammonia is liable to damage all types of compressors.

Worn, poorly aligned and out of balance machinery can cause excessive vibration and premature failure of piping and components with possible release of ammonia.

Liquid ammonia has a high coefficient of thermal expansion. Care should be taken to ensure that liquid ammonia is not trapped in pipelines or fittings between shut off devices. A rise in ambient temperature may be sufficient to expand trapped liquid, generate excess pressure and rupture components, resulting in release of ammonia.

2.2.6 Hot works

Welding and all sources of flame in contact with a refrigerating system constitute a hazard. The probability exists of a flammable ammonia/oil/air mixture being present within parts being modified. Precautions must be taken before brazing, welding or any operation involving a source of flame in contact with a refrigerating system. A risk assessment is required under the Management of Health and Safety at Work Regulations 1999. HSE Approved Code of Practice (ACOP) L138 “Dangerous substances and explosive atmospheres” and L101 “Safe work in confined spaces” may also apply.

2.2.7 Working in confined spaces

The precautions to be taken before persons are permitted to enter a vessel or similar confined space where there is a risk of them being overcome by dangerous fumes are set out in Confined Spaces Regulations 1997. These precautions should be followed in other premises in order to comply with the general requirements of the Health and Safety at Work Act 1974. HSE document L101 entitled “Safe Work in Confined Spaces” contains advice on the procedures and safeguards, which are essential to such work. Attention is drawn to the dangers of entering or working on vessels which have formed part of an ammonia system; even after air samples from the vessel appear clean, oil/ammonia mixtures remaining in the vessel can release hazardous quantities of ammonia when disturbed.

2.2.8 Corrosion

Corrosion can occur on the external surfaces of the steel piping and vessels used for ammonia refrigerating systems, reducing the strength of the containment and eventually resulting in leaks. Corrosion of unprotected steelwork can be rapid in wet or damp conditions; such conditions often occur on the low-pressure side of the system when metal temperatures are below the dew point of
the ambient atmosphere. Insulation where the vapour seal is defective or incomplete will not prevent condensation and may enhance corrosion; corrosion usually occurs relatively slowly on lines permanently below 0°C but has been found to be particularly rapid on pipes such as hot gas defrost lines where dampness and heat are present together.

Internal metal surfaces of ammonia refrigerating systems characteristically have a protective oil coating, by virtue of the compressor lubricating oil becoming entrained within the ammonia flow. It is therefore rare to find internal corrosion in operating systems. Systems out of operation for long periods can however corrode, particularly if open to atmosphere.

In systems deliberately designed to be oil free, internal corrosion may occur.

Where heat-transferring liquids such as potassium formate, calcium chloride or sodium chloride solutions are present they may form an additional source of corrosion. Chemical treatments of such solutions are prescribed by the suppliers of chemicals and should be adhered to rigorously.

### Table 1. Refrigerant Information

<table>
<thead>
<tr>
<th>Safety Group</th>
<th>Refrigerant Number</th>
<th>Formula and Common Name</th>
<th>NBP (°C)</th>
<th>AIT (°C)</th>
<th>Molecular Mass</th>
<th>Practical Limit (kg/m3)</th>
<th>Toxicity (OEL) (ppm v/v)</th>
<th>Lower Flammability Limits (LFL) kg/m3</th>
<th>% v/v</th>
<th>GWP</th>
<th>ODP</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2</td>
<td>R-717</td>
<td>NH3 (ammonia)</td>
<td>−33</td>
<td>630</td>
<td>17</td>
<td>0.00035</td>
<td>25</td>
<td>0.116</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Practical limits are taken from Tables E.1, E.2 and E.3 of BS EN378-1:2016 or are obtained as described in Annex F of BS EN378-1:2016

### Table 2. Example of Test Pressures for Specified Design Temperatures (32°C ambient or less)

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Reference temperature (°C)</th>
<th>Max Allowable Pressure PS</th>
<th>Strength pressure test (components)</th>
<th>Strength pressure test (assembly)</th>
<th>Tightness test 1.0× PS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Individual 1.43× PS</td>
<td>Individual 1.43× PS</td>
<td>Piping and joints 1.1× PS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Type approved 3× PS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-717</td>
<td>55</td>
<td>22.0</td>
<td>31.5</td>
<td>66.0</td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>15.8</td>
<td>22.6</td>
<td>47.4</td>
<td>22.6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>11.3</td>
<td>16.2</td>
<td>33.9</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>9.6</td>
<td>13.7</td>
<td>28.8</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Note 1: Withstanding a strength test pressure is only one of several criteria which have to be complied with to ensure safety. Successful completion of a strength pressure test does not prove that a system will be safe in use.

Note 2: All pressures given in the table above are in bar gauge.

Note 3: The specified design temperatures for ambient conditions of ≤32°C are as given in BS EN378-2:2016. Test pressures for refrigerants not included in this table shall be derived from the saturated liquid pressures at the reference temperature.

Note 4 – Specified design temperatures

- High pressure side with air cooled condenser 55°C
- High pressure side with evaporative condenser 43°C
- Low pressure side with heat exchanger exposed to the outdoor ambient temperature 32°C
- Low pressure side with heat exchanger exposed to the indoor ambient temperature 27°C
Section 3 – Design of Components

3.1 General

All materials in contact with the refrigerant shall be suitable for use with ammonia, comply with pertinent rules and codes and meet system pressure/temperature requirements.

Components in contact with ammonia shall not contain mercury. Copper, zinc, cadmium and alloys of these materials, and rubber shall not be used unless their compatibility has been previously established.

The attention of those selecting components is drawn to The Pressure Equipment Directive (PED) (2014/68/EU) and to The Pressure Systems Safety Regulations 2000 (PSSR) and the Approved Code of Practice (L122 “Safety of Pressure Systems”). Amongst other things these regulations impose on the user an obligation to draw up and carry out a regular programme of inspection and testing of vessels, pipework and safety devices at intervals appropriate to the system and its application. Where the system application is such that it cannot be released from service for a period adequate for inspection and test, the designer may need to incorporate features such as duplication of items of equipment to allow the user’s obligations to be met.

Designers and Users should note that regulations governing emission of refrigerants to the atmosphere, the EC Regulations 1005/2009 (Substances that Deplete the Ozone Layer), the EC Regulation 517/2014 (F Gas Regulations), do not apply to ammonia. However, it is good practice to minimise leakage from a system and the Institute of Refrigeration Code of Practice “Minimisation of Refrigerant Emissions” provides useful guidance.

Attention is also drawn to the Pressure Equipment Directive 2014 (PED) and Pressure Equipment Regulations 1999 (PER). All relevant components must be CE-marked to demonstrate conformity to the relevant directives.

3.2 Component Design and Test Pressures

The design pressures for refrigerating system components shall not be less than the maximum allowable pressure (PS) for the system. The PS shall not be less than the saturation pressures corresponding to the following temperatures (Table B1 in Appendix B of this Code and BS EN378-2:2016 Table 2), which is based on a design ambient of ≤ 32°C:

a. 55°C for the high pressure side with air cooled condenser.
b. Maximum leaving water temperature plus 8 K, for the high pressure side with water cooled condenser or hot water heat pump.
c. 43°C for the high pressure side with an evaporative condenser
d. 32°C for the low pressure side of a non-reversible heat pump (the out-door air cooled unit).
e. 27°C for low pressure side with heat exchanger exposed to indoor ambient.

These saturation pressures cover typical conditions encountered in the United Kingdom. However where particular working conditions require PS in excess of the above values then the design pressures, the strength test pressure, and the tightness test pressure range for the components shall be increased accordingly.

Design pressure and maximum allowable pressure as used here have the meanings as given in Appendix A: Definitions. They are necessarily higher than any normal system operating pressure to
allow for such factors as build-up of non-condensable gases prior to purging and margins between operating pressure, pressure limiting device, switching pressure and relief valve setting. In general low condensing pressures are preferred, so that power consumed is reduced, heat extraction capacity increased and equipment life prolonged.

Allowance should be made for:

a) Condenser sizing: care must be taken not to undersize evaporative or air-cooled condensers.
b) Non-condensables: air and other non-condensable gases may accumulate in the system
c) Condenser location: The air entering an air-cooled condenser may be above the nominal ambient temperature if the condenser is in a sheltered location subjected to sunlight. Where restricted space is available around condensers or where units are located close together, discharge air may recirculate, resulting in an increase in the air inlet temperature to the condenser.
d) Specific applications such as heat pumps where the ambient air temperature may be irrelevant.

Unless otherwise specified in a design and construction standard to which the component is made, the strength test pressure and the tightness test pressure shall be not less than the values shown in Table 2 of this Code.

Where different test pressure factors are called for in a standard to which a component is manufactured then the component tests shall be in accordance with the methods and pressure levels defined in that standard but the component design pressure shall not be less than the PS for the relevant part of the system given in Table B1 of this Code. The strength test pressure shall not be less than that given in Table 2 or 1.43 times the maximum allowable pressure (PS). This latter requirement is to ensure that testing of the completed system detailed in Section 5 of this Code. can be carried out without exceeding the strength test pressure of an individual component.

PD5500:2015 specification for unfired fusion welded pressure vessels for example uses a strength test factor of 1.25 so that where pressure vessels are designed to that standard it may be necessary to use a higher design pressure in order that the strength test pressure will meet the requirement of this Code.

Individual or type-test certificates should be made available by manufacturers and requested and retained by installation contractors.

The setting of pressure limiting and relief devices is determined from PS. Figure 1 shows a flowchart of the requirements for these devices.
Figure 1 Flow chart for determining pressure limiting and pressure relief devices
3.3 Compressors

3.3.1 General

The type of compressor may be centrifugal, reciprocating, scroll, rotary vane or screw. Systems can require compressors to operate as single stage or for any of the stages of a multi-stage system, or in a compound arrangement where more than one stage of compression occurs within the same compressor. Not all compressors are suitable for all of these applications.

3.3.2 Design Criteria

The design pressures shall be determined in accordance with Section 3.2 such that:

a. design pressure for the high-pressure side of single-stage compressors, and the high pressure side of the high stage of multi-stage compressors shall be not less than the saturated pressure equivalent to a temperature of 43°C or 55°C as appropriate to the method of condensing;

b. design pressure for the low pressure side of single-stage compressors, for the low pressure side of the high stage of multi-stage compressors and for the high and low pressure sides of the lower stages of multi-stage systems shall be not less than the saturation pressure equivalent to 32°C;

c. Where the system has only high pressure relief valve protection, both high and low pressure sides of all compressors shall have a design pressure not less than the saturation pressure equivalent to 43°C or 55°C as appropriate to the method of condensing.

Positive displacement compressors with a nominal swept volume greater than 90 m³/h (25 l/s) shall be protected against rupture by a compressor pressure relief device or an ordinary pressure relief device. This valve shall be selected to relieve the full mass flow of the compressor under all foreseeable operating conditions, including pull down.

Compressor damage from overheating could result if a compressor pressure relief device operates.

If a discharge stop valve is fitted, the compressor pressure relief device shall be between the compressor and the discharge stop valve. The relief device shall relieve to a lower pressure stage of the system or to a special container. The compressor pressure relief device shall not serve as system protection.

Each compressor shall be provided with a type-approved safety-switching device for limiting the pressure (high pressure cut-out). The cut-out shall be of the manual reset type and, for positive displacement compressors, set to operate at a pressure less than the maximum allowable pressure and significantly less than (say 90% of) the setting of any pressure relief device. For non-positive displacement compressors a type approved limiting device, pressure relief device or surge protection device shall be provided. This cut-out shall comply with the requirements of BS EN378:2016 and shall be a Category 4 device in accordance with the PED.

Compressors in multi-stage and compound systems shall be protected against over-pressure as above; additional measures such as the use of automatic reset high-pressure cut-outs may be necessary for control purposes to ensure the protection of the compressor during starting and pull-down conditions.

Where the rotation of an open drive compressor is allowable in one direction only, the direction of rotation shall be clearly marked with a permanently attached arrow.
Where compressors are equipped with oil heaters (energised when the compressor is not running to reduce absorption of the refrigerant into the oil and hence the possibility of mechanical failure) the surface temperatures of such heaters shall not exceed 80°C.

Where the compressor lubrication depends on pressure a low pressure cut-out shall be provided. Where the compressor is splash lubricated a level switch should be fitted where possible. Where there is a potential hazard from low pressure (e.g. a risk of freezing a secondary fluid) a low pressure limiting cut-out shall be provided. A high temperature cut-out should be fitted in the discharge of each compressor. These cut-outs may be hard-wired electromechanical devices or may be provided by software in an electronic controller.

3.3.3 Pressure Testing

Compressors shall be pressure tested for strength and tightness by the manufacturer. This test can be a type test, in which case a sample is tested at a pressure of at least 3 x PS given by the manufacturer, followed by an individual test in which each compressor is subject to a test of at least 1.1 x PS. Alternatively, where specified, the test can be an individual strength test where the high and low pressure sides are tested in accordance with section 3.2 of this Code.

3.3.4 Nameplate Data

A nameplate carrying the information required in Appendix D of this Code shall be securely attached to the compressor where it can be read easily.

3.4 Pressure Vessels and Heat Exchangers

3.4.1 General

This section applies to high pressure and low-pressure vessels and heat exchangers.

3.4.2 Design Pressures

The design pressures shall not be less than those given in section 3.2 of this Code.

Where evaporators are subject to hot gas defrosting or reverse cycle defrosting then the design pressure of the evaporator and other affected parts of the system shall be increased to that appropriate to the high-pressure side of the system.

3.4.3 Test Pressures

Each completed vessel or heat exchanger shall be subjected by the manufacturer to a pressure test for strength, followed by a pressure test for tightness. These tests shall be in accordance with the methods and pressure levels defined in the standard to which it is manufactured but design pressures shall not be less than those specified in section 3.2 of this Code.

3.4.4 Nameplate Data

A nameplate which complies with the standard to which the pressure vessel or heat exchanger is made and which carries at least the information required in Appendix D of this Code shall be securely attached to the pressure vessel or heat exchanger where it can be read easily.
3.4.5 Pressure Vessels

The pressure vessels covered by the requirements in sections 3.4.2 to 3.4.4 of this Code are those that exceed 150mm inside diameter and include high and low pressure ammonia receivers, discharge line oil separators, flash intercoolers, shell and coil intercoolers, suction line accumulators or separators, surge drums and purge vessels.

Pressure vessels shall be designed and manufactured in accordance with appropriate national standards such as:

- PD5500 – Specification for unfired fusion welded pressure vessels
- EN 13445 – Unfired pressure vessels
- EN 14276-1 – Pressure equipment for refrigerating systems and heat pumps. Vessels. General requirements
- BS 7005 – Specification for design and manufacture of carbon steel unfired pressure vessels for use in vapour compression refrigeration systems.
- ASME VIII – Boiler and pressure vessel code: Division 1 Pressure Vessel

Consideration should be given to the possibility of stress corrosion cracking occurring in vessels and pipes exposed to ammonia. Previous experience together with the particular details of the installation should be used to help interpret the necessary provison. Stress corrosion cracking has been shown to be more likely in warmer parts of the system and where oxygen is likely to be present. For this reason, it is recommended that high-pressure liquid receivers are stress relieved by appropriate heat treatment after manufacture.

3.4.6 Shell and Tube Heat Exchangers

The shell and tube heat exchangers covered by the requirements of sections 3.4.2 to 3.4.4 above include evaporators of the flooded type with the ammonia in the shell, evaporators of the direct expansion type with ammonia in the tubes, gravity or pumped circulation types with ammonia in the tubes and gravity condensers with ammonia in the shell.

The heat exchangers shall be designed and manufactured in accordance with appropriate national standards such as:

- BS EN 14276 Pressure equipment for refrigerating systems and heat pumps
- PD5500 - Specification for unfired fusion welded pressure vessels.
- BS EN 3274 Tubular heat exchangers for general purposes
- ASME VIIo – Boiler and pressure vessel code: Division 1 Pressure Vessels
- TEMA Standards of Tubular Exchange Manufacturers’ Association

The design pressure of the ammonia side shall be determined as in section 3.2 but due account must also be taken of the effect of possible pressures and temperatures on the non-ammonia side of the heat exchanger as detailed in the standard to which the unit is designed.

3.4.7 Coil or Grid Exchangers

These exchangers, which are covered by the requirements in 3.4.2, 3.4.3 and 3.4.4 above include evaporators, air cooled condensers and evaporative condensers. The exchangers shall be designed and manufactured to appropriate national standards such as those below, taking due account of
ferrous or non-ferrous construction:

- BS 2633 – Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids
- BS 4677 – Specification for arc welding of austenitic stainless steel pipework for carrying fluids
- ASME B31.5 - Section 5 Piping for refrigeration

3.4.8 Plate and Plate & Shell Heat Exchangers

These exchangers, which are covered by the requirements in 3.4.2 to 3.4.4, include evaporators, condensers and ammonia/ammonia heat exchangers used, for example, as sub-coolers.

The exchangers shall be designed and manufactured to appropriate standards.

Any jointing material used in the construction shall be checked for compatibility with ammonia and with the lubricants being used.

3.5 Liquid Ammonia Pumps

3.5.1 Design Criteria

The pump design pressures shall not be less than those derived in section 3.2 and section 3.4.2.

All liquid ammonia pumps that can be isolated shall be protected against excess pressure due to temperature rise. This shall be by use of a locked valve on the pump suction in accordance with BS EN378:2016 or by a pressure relief device preferably venting to the low-pressure side of the system, or alternatively to atmosphere.

Positive displacement pumps shall be protected against excess pressure during operation by the fitting of a pressure relief valve connected to the discharge line between the pump and any stop valve. This pressure relief valve shall vent to the low pressure side of the system and shall be sized to limit discharge pressure to a pressure not exceeding the PS. Depending on the particular piping arrangement adopted this valve may be combined with, or may be in addition to, the protection provisions related to temperature rise.

3.5.2 Test Pressures

Each pump shall be subjected by the manufacturer to a pressure test for strength, followed by a tightness test. These tests shall be to pressure levels not less than those in accordance with section 3.2 of this Code.

3.5.3 Nameplate Data

A nameplate carrying the information required in Appendix D of this Code shall be securely attached to the pump where it can be read easily.

3.6 Ammonia Control Valves and Sensing Devices

3.6.1 General

This section applies to components that are in contact with the ammonia or its associated lubricating oil. Products covered include:

- Shut off and service valves
Relief valves
Solenoid valves
Expansion valves
High pressure float valves
Low pressure float valves
Oil drain float valves
Automatic liquid ammonia drain valves
Non Return valves
Motorised valves
Pilot operated valves
Evaporator pressure regulators
Suction pressure regulators
Hot gas by‐pass regulators
Flow regulators
Ammonia pressure actuated condensing pressure regulators
Liquid level indicators
Other similar components.

3.6.2. Design Pressure and Temperature

The design pressure and temperature of any valves or components that are in contact with ammonia shall be not less than that appropriate to the system or part of the system in which they are incorporated (see section 3.2).

3.6.3. Manufacturing Tests

3.6.3.1 Pressure Test

Where the ammonia containing volume of the device is greater than 0.5 litre then the pressure tests for strength, tightness and flow leakage shall be mandatory. Each completely assembled control valve or sensing device should be subjected by the manufacturer to a pressure test for strength followed by a pressure test for tightness at pressures not less than those required by section 3.2 of this Code. The device shall not leak under this latter test when subject to inspection under clean water or other suitable fluid or using another tightness detection method of equal or greater sensitivity.

The requirements for pressure tests and for functional tests in relation to small control valves and sensing devices (with an internal volume less than 0.5 litre) have not been made mandatory because it is recognised that certain items such as shut‐off valves are produced in quantity and functional and pressure testing may be based on statistical production control rather than for each component.

Control valves and sensing devices shall be of a traceable origin. Suitability for purpose in relation to ammonia, function, pressure and temperature ratings shall be verified by a competent person before installation.

3.6.3.2 Functional Test

Each completely assembled control valve or sensing device should be subject to a manufacturer’s test using suitable fluid which will simulate field performance of the moving parts of the valve or
device in a manner which will determine that the completed device functions correctly.

3.6.4 Nameplate Data

A nameplate should be securely attached to the valve or sensing device; it should carry the following information as relevant:

a) Manufacturer
b) Model and/or serial number
c) Test pressure applied
d) Maximum working pressure
e) Refrigerant R717 ammonia
f) Electrical voltage/current/frequency
g) Pneumatic or hydraulic actuation, fluid pressure and range.

Relief valves shall be marked in accordance with BS EN378-2:2016.

3.6.5 Shut-Off Valves

Only those designs of shut-off valves which comply with BS EN378-2:2016 and BS EN12284:2003 Refrigerating systems and heat pumps. Valves. Requirements, testing and marking shall be used.

The following requirements shall be met:

a) If it is not possible to tighten or change the gland packing/seal(s) while the valve is exposed to system pressure, it shall be possible to isolate the valve.

b) Construction shall be such that the unintentional turning out of valve spindles and/or covers shall be prevented.

c) Shut-off valves for use at any time (process valves) shall be fitted with rigidly mounted hand wheels or other operating element. System design should allow for access to and operation of such valves including where necessary appropriate measures to guard against valves being rendered inoperable by external build-up of ice.

d) Shut-off valves not required during the operation of the system (for facilitating repair and for maintenance) need not be provided with operating handles; they may be capped valves.

e) Valves with operating handles are preferred providing arrangements are provided to prevent unauthorised use.

f) The design of capped valves shall be such that any ammonia under pressure which might be under the cap shall be safely vented as removal is commenced: for example a drilled hole uncovered by turning the cap or a broached slot down the length of the cap thread could be used.

3.6.6 Liquid level indication

Any liquid indication or measuring device should be suitable for the application and comply with BS EN 12178:2016 Refrigerating systems and Heat Pumps – liquid level indicating devices. Requirements, testing and marking.
Section 4 – System Design and Installation

4.1 General

The refrigerating system shall have been designed by, and installed under the supervision of persons who by reason of knowledge, training and experience are competent for the tasks; refer to Construction (Design and Management) Regulations 2015, BS EN 13313: 2010 Refrigerating Systems and Heat Pumps - Competence of Personnel, BS EN 14276 Pressure equipment for refrigerating systems and heat pumps, Part 1: vessels – General Requirements and Part 2: Piping – General requirements and BS EN 60079-10-1: 2015 Explosive atmospheres, classification of areas.

Such persons might include:

a) Experienced refrigeration installation contractors, and commissioning engineers possibly in combination with a Design Approval Authority, or an Engineering Insurance Company
b) In house design/engineering staff of the user
c) Consulting Engineers, acting on behalf of the user
d) Manufacturers

Refrigerant charge size limits are defined in BS EN 378-1:2016 Annex C.

4.2 Material Selection

All materials used in systems shall be checked to be compatible with anhydrous ammonia and with the lubricating oil chosen. General guidance is given in BS EN378-2:2016.

Components in contact with ammonia shall not contain mercury. Copper, zinc, cadmium and alloys of these materials, and rubber shall not be used unless their compatibility has been previously established.

The material shall comply with all applicable codes and standards as noted below and shall be appropriate for the pressure and temperature requirements of the system.

4.3 Steel Piping Systems

4.3.1 Pipe Materials

Carbon steel, alloy steel or stainless steel interconnecting piping may be used. The grade and type of pipe shall be chosen with regard to the lowest service temperature, appropriate design pressure, pipe-wall thickness and test procedures in compliance with a recognised and applicable national or international standards (these include these include BS EN 14276-1:2006 Pressure Equipment for refrigerating system and heat pumps (vessels) and BS EN14276-2:2007 (+ A:2011) Pressure Equipment for refrigerating systems and heat pumps (piping), and EN 13480:2012 Metallic industrial piping)

If for operational reasons flexible hoses are required, the manufacturer shall confirm their suitability for ammonia service. They shall be adequately protected against mechanical damage, torsion and stress.

Flexible bellows should be avoided where possible and should only be used within the recommendations of their manufacturers. Adequate precautions shall be taken to avoid excessive vibration, mechanical damage, torsion and stress.
Guidance on selection of flexible connections may be found in BS EN 1736:2008 Flexible Pipe Elements, Vibration Isolators, Expansion Joints and Non-metallic tubes.

4.3.2 Pipe Connections

4.3.2.1 General

Welded joints should be used wherever practicable to reduce the probability of leaks, flanged joints being limited to connections with compressors, vessels, valves and branches for future plant extension or where required for maintenance purposes. For 40mm (1½in.) nb pipe and smaller or where correct alignment could be difficult to ensure such as when welding on site, socket weld connections should be used in preference to butt-welded joints. The number of joints, flanged or welded, should be kept to a minimum by careful design and the use of the longest possible pipe lengths.

Welding should be carried out as far as is practicable in a controlled environment such as a workshop and pipework manufactured thus should be subjected to a hydraulic or pneumatic strength test prior to use on site. The pneumatic test, in accordance with section 5.2 of this Code, shall be preferred where there may be difficulty drying the pipework after testing. Rotated down hand welds are preferred, “in situ” positional welds should be kept to a minimum. The proposed location of site welds should be checked carefully at the design stage to ensure that there is adequate access for welding, cleaning, inspection and non-destructive testing. On-site welding will require extra care and should be executed away from flammable insulation materials and obstructions, positional welding being kept to a minimum.

For the purposes of this Code a header is to be considered as pipework and designed in accordance with the design code which has been adopted. However, because of their vulnerability to failure flat ends should be avoided and full penetration welded end caps to BS EN 10253-2:2007 Butt-Welding Pipe Fittings, or similar should be used.

4.3.2.2 Specific Requirements

The welding of steel ammonia pipework and fittings shall be to an appropriate international standard and suitable for the pressure and temperature limits applicable.

BS EN378-2:2016 sets out requirements for detachable joints, flanged joints and screwed joints.

Permanent welded joints shall be used in accordance with BS EN 14276-2:2007 (+A1:2011).

All flanges and fittings shall be compatible with the grade of pipe selected and suitable for the lowest service temperature and highest design pressure required.

Welding shall be to approved procedures which shall be detailed on the installation specification.

All pressure containing components must be manufactured, installed and tested in accordance with the Pressure Equipment Regulations. Material specifications, welding procedures, non-destructive testing (NDT) procedures, welding and welder qualifications must be checked and documented in accordance with the codes and standards required by the PED and, where appropriate, approved by the appropriate notified body.

Care should be taken to exclude ammonia where any welding is to be undertaken. This can be
achieved by purging the pipe section with oxygen-free nitrogen or argon.

Where independent inspection is specified, the inspector shall be satisfied that the material and the welding methods used are in accordance with the procedures specified, that the qualifications of the operatives are appropriate and recorded and that the welded joints are in accordance with the requirements of an appropriate British, European or International Standard.

4.3.2.3 Gaskets and Joints

Particular care should be taken in selection of gasket, O-ring and jointing materials. In addition to their suitability for use at the design pressure and temperature, their compatibility with ammonia and with lubricating oils should be rigorously checked. Metallic joint rings should be of soft iron or aluminium. Rings or seals of Nitrile or Neoprene rubber are generally satisfactory within the temperature limitations as recommended by the manufacturers. Gaskets containing asbestos shall not be used.

4.3.2.4 Bolting

Bolting materials should be carefully checked for suitability at the operating temperatures expected. All bolting of pipeline connections shall be in accordance with PD5500 Unfired Pressure Vessels or BS EN 4882:1990 Specification for Bolting.

4.3.2.5 Screwed Joints

Wherever possible the use of screwed joints should be restricted in application as indicated in BS EN378-2:2016 clause 6.2.3. Taper pipe fittings and sealing medium shall be type approved by the manufacturer in regard to tightness. If thread sealant is used, compatibility with ammonia and lubricating oil shall be ensured. Liquid thread sealant should not be used to excess. Olive-type compression fittings may be considered as a possible alternative but restricted to a maximum size of DN40.

4.3.3 Pipe Supports and Hangers

All ammonia piping shall be adequately supported, the supports or hangers being designed to carry the weight of pipe including contents and, where required, insulation. Particular attention should be paid to pipework that could operate full of liquid.

The distance between supports depends on the size and service weight of the pipeline: a recommended maximum spacing for steel pipes is as follows:

<table>
<thead>
<tr>
<th>Steel pipe sizes nominal bore (mm)</th>
<th>Maximum spacing of supports (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 – 25</td>
<td>2</td>
</tr>
<tr>
<td>32 – 50</td>
<td>3</td>
</tr>
<tr>
<td>65 – 80</td>
<td>4.5</td>
</tr>
<tr>
<td>100 – 175</td>
<td>5</td>
</tr>
<tr>
<td>200 – 350</td>
<td>6</td>
</tr>
<tr>
<td>400 – 450</td>
<td>7</td>
</tr>
</tbody>
</table>
4.4 Copper Pipework

Copper pipework is not compatible with ammonia refrigerant and shall not be used.

4.5 Location and Arrangement of Piping

The clearance around pipelines shall be sufficient to allow any necessary access to flanges, screwed joints and fittings. This is particularly important because the user has to ensure that the system is properly maintained in good repair, in accordance with the requirements of the Pressure Systems Safety Regulations:2000 (PSSR). There is also a requirement to examine those parts of the pipework in which a defect may create a hazard. Any such pipework shall be specified in the Written Scheme of Examination, which the Regulations require to be drawn up by a competent person. Pipework shall be arranged so as to avoid obstructing access ways and inhibiting access to plant.

The clearance around pipes passing through fire resisting walls and ceilings shall be sealed to maintain the integrity of the fire compartmentation. Pipe ducts and shafts shall be isolated from other rooms in such a way as to resist the spread of fire.

Consideration shall be given to the need to provide adequate flexibility in piping to allow for thermal movement. Flexible hoses and bellows shall be protected.

Piping, valves and fittings particularly where located less than 2m above the floor should be adequately protected against accidental damage. Overhead pipelines should be fixed as high as reasonably practicable. Channels or ducts for ammonia piping should contain no other pipelines or electric wires unless they are adequately separated and protected against condensation.

Where piping and machinery are located in occupied spaces, the maximum permissible charge of ammonia is set out clearly in Table C1 of BS EN378-1:2016. In considering this maximum charge, the provisions of the Control of Substances Hazardous to Health Regulations 2002 (COSHH) and the associated occupational exposure limits published by the Health & Safety Executive in the current edition of document “Workplace Exposure Limits” EH40 shall be followed.

Ammonia piping shall not be located in lift wells, public lobbies, hallways, stairways, stairway landings, entrances or exits. The pipe route shall be chosen to avoid potential contact of the pipe with any obstruction or other pipes.

Ammonia which has been released through the operation of a pressure relief device, shall be discharged to a safe place. If the discharge is to atmosphere, ammonia shall be vented via a pipe as required in BS EN378-2:2016 clause 6.2.6.6 and Section 4.7 of this Code, and at sufficient height to prevent local hazard or nuisance. Alternatively it may be discharged into an absorbing medium. Refer to BS EN60079-10-1:2005 Explosive atmospheres. Classification of areas. Explosive gas atmospheres.

A means of decanting and/or pumping out shall be provided so that ammonia and oil can be safely removed.

An identification system shall be used on pipes assembled and installed on site; colour coding to BS1710:2014 Specification for identification of pipelines and services should be used with wording or other addition to distinguish between high and low-pressure piping and liquid or vapour pipelines. Identification of refrigerant as ammonia (R717) should be included, in particular near valves and where walls are penetrated.
Suction pipes shall be arranged so that the possibility of liquid being drawn back to the compressor is minimised.

Where appropriate it is recommended that all valves and demountable joints in ammonia pipework serving air coolers should be arranged outside the refrigerated space.

4.6 Arrangement of Isolating Valves

To minimise danger and loss of ammonia, machines and apparatus shall be equipped, as appropriate, with isolating valves. Requirements for manually operated valves are set out in BS EN378-2:2016 clause 6.2.4.

Access to isolating valves as described above shall be such that the valves can be reached and operated in safety. Isolating valves should be identified, for example by numbering in relation to a circuit or piping diagram of the installation.

4.7 Instrumentation

4.7.1 General

All systems shall be equipped with adequate measuring and indicating instruments for normal operation. Instruments shall be adequate for all foreseeable conditions within which the system is expected to operate.

4.7.2 Arrangement of Pressure Indicators

Where the ammonia charge exceeds 10kg, the system shall be equipped with connections for suction and discharge pressure indicators. The fitting of permanent pressure indicators is optional.

Positive displacement liquid pumps shall be fitted with suitably damped pressure gauges on the discharge side. Note: A pressure transducer with suitable instrumentation is equivalent to a pressure gauge.

Pressure vessels requiring testing shall be provided with valved pressure indicator connections separate to and remote from the test pressure connections.

Apparatus that is manually defrosted by manipulating valves shall be equipped with pressure indicators.

4.7.3 Liquid Level Indicators on Refrigerant Receivers

Refrigerant receivers in systems containing more than 25kg of ammonia and which can be isolated shall be provided with a liquid level indicator to show at least the maximum liquid level. The test pressure for a liquid level indicator shall be at least equal to that for the part of the system to which it is fitted.

4.7.4 Liquid Level Glasses

Liquid level glasses installed in low temperature services and which require insulating should be equipped with appropriate extension to accommodate the insulation and secure visibility without ice
4.8 Protection against Excess Pressure

BS EN 378-2:2016 clause 6.2.6 sets out in detail requirements for pressure protection. This includes safety valves, bursting discs and other pressure limiting devices including, for example, high pressure cut out switches.

For ammonia Annex A of BS EN 378-2:2016 requires the use of dual relief valves for all systems with a charge greater than 50kg.

Note: BS EN 378-2:2016 clause 6.2.6.6 allows combinations of pressure relief valves and bursting discs in series to be used, but this is not recommended for ammonia systems.

Fusible plugs shall not be used for protection against excess pressure.

For systems with a charge of at least 300 kg of ammonia an indication device shall be provided to check during maintenance whether the relief valves have discharged to atmosphere. BS EN 378-2:2016 clause 6.2.6.5 provides five examples.

4.9 Protection against Environmental Effects

All protection devices and pipelines shall be protected against adverse environmental effects such as water collecting and freezing in relief discharge pipes, dirt or debris causing malfunction of equipment, or other problems.

Steel piping in particular is subject to external corrosion and shall be adequately protected. For pipes which will have a surface temperature below normal atmospheric temperature or which are in humid areas, protection against the effects of condensation should be provided. Where pipes are insulated, the insulation shall incorporate adequate vapour barriers to prevent condensation or ice forming on or near the pipe surface.

4.10 Notification to Local Authorities

The installation of Cooling Towers and Evaporative Condensers must be notified to the Local Authority under the Notification of Cooling Towers and Evaporative Condensers Regulation 1992.

4.11 Refrigerant Detection

The requirements for ammonia detectors are laid down in BS EN 378-3:2016. If the ammonia charge exceeds 3000kg then a permanently attended station shall be provided as a central alarm station. Specialised personnel shall be present on site within 60 minutes of an alarm. The personnel may also be informed of the alarm by mobile telephone or pager.

4.12 System Labelling

Ammonia refrigerating systems shall be labelled with an identification plate. The content of the identification plate shall be as specified in EN378-2:2016 paragraph 6.4.2.2. This requires the information to include the name and address of the manufacturer, a unique reference number, the year of manufacture, the refrigerant designation R717, the refrigerant charge, the maximum allowable pressure (PS), the flame symbol given in ISO 7010-W021 and details of relevant electrical
data for the system. Where the system is to be placed on the market in the EU the CE mark and any auxiliary marking shall be included on the identification plate.

4.13 Allowable Refrigerant Charge

The refrigerant charge limit for which the system is designed shall be calculated according to Table C.1 and C.2 of Annex C in EN378-1:2016.

The appropriate access category and location classification shall be determined. The charge limit is then found in Table C1 for toxicity class B or in Table C2 for flammability class 2L. In general it is likely that the maximum permitted charge of ammonia in access category a, and in location classification I will be too small for practical systems. In table C1 (toxicity) for access categories b and c and location class II and III the charge is restricted to 25kg unless the density of personnel is less than 1 person per 10m² in which case there is no restriction of charge. In table C2 (flammability) the charge is restricted to 20% x LFL x room volume and not more than 25kg unless the density of personnel is less than 1 person per 10m² in which case there is no restriction of charge. For ammonia this gives a value of 0.0232 x room volume as the allowable refrigerant charge if the room is smaller than 1,075m².

4.14 Protection for Indirect Circuits

When ammonia is used in indirect systems, release of the refrigerant into the areas served by the secondary heat transfer fluid, due to leakage through the evaporator or condenser wall shall be prevented. This may be achieved by implementing at least one of the following options.

a. A double wall heat exchanger, between the primary and the secondary circuit, in order to avoid refrigerant leakage into the secondary circuit as shown in BS EN 378-1:2016 clause 5.5.2.2
b. The design shall ensure that the pressure of the secondary circuit is always greater than the pressure of the primary circuit in the area of contact as shown in BS EN 378-1:2016 clause 5.5.2.5
c. Use of a double indirect system as shown in BS EN 378-1:2016 clause 5.5.2.4

Where the ammonia charge exceeds 500kg detectors shall be incorporated in the heat transfer circuit of indirect systems, for example water or glycol circuits, to detect the presence of ammonia in the circuit. These detectors shall initiate an alarm in the machinery room, and where practicable in the control system operator interface, but they shall not trigger beacons or klaxons, and they shall not initiate an evacuation.

4.15 Additional Requirements for Ammonia

Additional requirements for refrigerating systems and heat pumps relating to system charge, liquid pumps and emergency stop systems are required in BS EN 378-2:2016 Appendix A.
Section 5 – System Testing

5.1 General

Before systems are put into service they shall be pressure tested for mechanical strength.

Before systems are put into service they shall be subjected to a tightness test to permit detection of leak. A pressure test for strength shall precede the pressure test for tightness except that a tightness test at very low pressure, not more than 2 bar gauge, may be carried out to verify system integrity prior to the pressure test for strength.

Compressors, condensers, evaporators, pressure vessels, safety devices, control mechanisms and complete systems that have been strength tested previously need not be subjected to a further strength test.

Prior to carrying out the system strength pressure test, relevant non-destructive testing to show that piping welds are in accordance with the welding standards applicable to the installation shall have been carried out and the results made available. If any weld failed to meet the required standard then further testing and remedial work as required by that standard shall also have been completed.

After any modification or repair to any system at least the affected part shall be subjected to appropriate non-destructive testing, sufficient to assure structural integrity during strength pressure testing and subsequent operation. Following this the affected part of the system may be tested for strength (see section 5.2) and shall be tested for tightness (see section 5.3 of this Code).

5.2 Strength Test Procedure

The test will normally be carried out pneumatically using oxygen free nitrogen (OFN) or other inert gas. Refer to guidance on strength pressure testing in BS EN 378-2:2016 Testing and HSE publication GS4 ‘Safety in pressure testing’. Oxygen, air, ammonia, fluorocarbons, combustible gas or any combustible mixture of gases shall not be used as a strength test medium.

The means to build up pressure for test purposes shall have a pressure-limiting device, reducing valve with gauge, or other device for preventing pressure being imposed in excess of that prescribed. High-pressure air shall not be used as it can form a combustible mixture when combined with ammonia. The use of a pneumatic strength test for the completed system assumes the previous strength test of system components by their manufacturer(s) as required by section 3.2 of this Code.

Manufacturer’s certificates for component strength test should be obtained by the system manufacturer and retained as part of the system documentation.

Prior to testing, gauges, sensitive instruments and controls that may be damaged by excess pressure shall be isolated from the system. Relief valves shall be removed and openings capped or plugged. Solenoid, pressure regulating, non-return or other control valves shall be opened as necessary and the circuit checked to ensure that all relevant parts of the system are pressurised appropriately.

The strength test shall be carried out at 1.43 times the maximum allowable pressure (PS) of the system or relevant part of the system, or at a pressure of 1.1 times the maximum allowable pressure where the requirements of BS EN 378-2:2016 clause 6.3.2 apply. The strength test pressure shall not exceed the strength test pressure applied to components by a manufacturer; this may require the testing of the low-pressure side of the system separately from the high-pressure side.
The pressure in the system shall be built up gradually and monitored by calibrated, remote gauge or other indicator located in a safe place.

During the strength test all personnel shall be evacuated from the area of risk and precautions shall be taken to minimise risk to property. Determination of the area of risk shall include consideration of the stored energy in the item being tested. Larger pipes and vessels require a larger exclusion area. If it is not possible to evacuate personnel then a hydraulic test shall be mandatory.

The full strength test pressure shall be held for at least the minimum time sufficient for the pressure to equalise throughout the system. The test shall be deemed satisfactory provided that no visible permanent distortion of any component or part of the system results from this test.

5.3 Tightness Test Procedure

The tightness test shall not be conducted until the strength test is satisfactorily completed.

The tightness test shall be carried out with oxygen free nitrogen (OFN) or a mixture of OFN and tracer. The tracer shall be zero ODP and low GWP for example helium or hydrogen. Oxygen, air, ammonia, fluorocarbon combustible gas, or any combustible mixture of gases shall not be used as a tightness test medium. Mixtures of refrigerants with air shall not be used.

The tightness test pressure shall be less than or equal to the allowable pressure (PS).

Prior to testing, all control valves should be open and all components in the circuit ready for system operation, except relief devices which may have been removed for the strength pressure test and can be refitted on completion of the tightness test.

All joints shall be checked for tightness using either a leak detecting bubble spray, an ultrasonic detector or an electronic leak detector suitable for use with a tracer.

The tightness test pressure shall be held for at least one hour; a longer period may be appropriate for larger systems where a fall in pressure may not be quickly apparent.

Due consideration should be given to ambient temperature fluctuations during the test period.

If any leakage is apparent the fault(s) shall be detected and rectified.

Repairs, particularly involving welding, shall not be carried out on any system, part of a system, or component while it is under pressure. Where appropriate the section of the system shall be purged prior to commencing hot work.

5.4 Test Certificates

After the above tests have been carried out and have proved satisfactory, a certificate shall be provided for the user. The certificate shall show at least the following data:

a. The name(s) of the manufacturer(s) or supplier(s)
b. Strength test pressures applied to the high-pressure side and the low-pressure side
c. Tightness test pressures applied to the high-pressure side and the low-pressure side
d. Duration of the test
e. Identification of system tested (or part of system if tested in sections)
f. Signature, name, competence, position and company of persons carrying out the test
g. Signature, name, qualifications, position and company of any test witnesses
h. Date of test.
Section 6 – Commissioning of New Installations

6.1 General

BS EN 378-2:2016 requires that a complete installation including the complete refrigeration system shall be checked against appropriate installation drawings, flow diagrams, pipe and instrumentation diagrams and electrical diagrams before it is put into operation. The inspection shall be carried out by a competent person and the results shall be documented before the system can be put into operation. Items to be included in the inspection are detailed in BS EN 378-2:2016 clause 6.3.4.

A typical procedure for commissioning has been included for guidance in Appendix F of this Code to which reference should be made. As a minimum, the following shall be included:

- The requirements of the Pressure Systems Safety Regulations 2000 requiring a written scheme of examination to be in place prior to the system being put to work
- The availability of Operating and Maintenance Manuals
- The keeping of commissioning records
- The requirements of DSEAR 2002
- The general requirements of Health and Safety legislation
- The Construction (Design and Management) Regulations 2015

For the purposes of this section it is assumed that the installation has been correctly designed for the duty that it is to perform, and that all piping, electrical equipment and thermal insulation have been installed. Prior to the initial operation of the compressor, all protection devices and system controls shall have been tested and set as close as possible to their design operating conditions and checked to ensure that they function in the correct sequence. It is assumed that the system has been strength tested and tightness tested in accordance with the procedure detailed in section 5 of this Code.

The Commissioning Engineer shall have relevant drawings, including a refrigeration circuit or flow diagram and an electrical circuit diagram, available on site, together with data relating to the design performance and the normal working and limiting design conditions. The Commissioning Engineer should be provided with ready access to those responsible for the design and installation of the refrigerating system and associated equipment.

Before the system is charged with ammonia, the machinery room, any other spaces containing parts of the system and their accesses shall be demonstrably in accordance with the requirements set out in BS EN 378-3:2016. The requirements in relation to machinery rooms, first aid and safety equipment shall be met prior to commencing the commissioning procedure and continued compliance with them shall be confirmed as part of a maintenance routine throughout the life of the system. For further guidance on these requirements see appendix G of this Code.

The Commissioning Engineer shall be provided with a commissioning specification and shall provide a formal method statement detailing the commissioning sequences and procedures to be employed for systems over 25kW installed power.

6.2 Evacuation and Dehydration

After the system has been strength and tightness tested as specified in section 5 of this Code, the inert gases shall be released from the plant in a safe manner before commencing the evacuation procedure.
Vessels that will contain or partially contain oil e.g. compressors, oil separators and oil reservoirs should be charged with suitable oil in accordance with the manufacturer’s instruction.

A vacuum pump shall be connected to both the high and low-pressure sides of the system and the plant evacuated as detailed in appendix F4 of this Code.

It is essential for reliable operation of the plant that all traces of non-condensable gases are removed from the plant prior to the charging process.

6.3 Charging

The charging line shall be appropriate for use in refrigeration applications. A flexible charging hose suitable for use with ammonia should be used between the cylinder and the charging point. Alternatively, if a rigid charging line is used, the configuration of the charging line shall provide flexibility. A pressure gauge may be connected into this line and the system should be charged as detailed in Appendix F4 of this Code.

Particular care shall be taken to avoid trapping liquid ammonia between isolating valves. Air shall be purged from the line before starting to charge the system.

Ammonia charging points shall be located in safe, well-ventilated positions, away from sources of ignition and, where reasonably practical, in the open air.

6.4 Protection Devices

When the system has been charged with ammonia and the compressor is operating, all the protection devices shall be tested for their correct function and adjusted where necessary in the following order (See Appendix F 5.1 to 5.6):

a. High pressure safety cut out
b. Oil pressure differential switch; both correct tripping and time delay duration
c. Low pressure switch, if fitted
d. Compressor high temperature cut out
e. All other pressure switches, limits and alarms.


Section 7 – Inspection and Maintenance

7.1 General

This section contains recommendations on the type and frequency of inspection and preventive maintenance required to ensure the safety of refrigerating systems. The Pressure Systems Safety Regulations: 2000 (PSSR) requires users to ensure that systems are properly maintained in good repair so as to prevent danger from stored energy.

For all systems over 25 kW total installed power input the PSSR require regular examination of the system in accordance with a written scheme certified by a competent person. Pressure vessels, pipework and relief devices shall be examined in accordance with the written scheme of examination.

If the product of pressure and internal volume is less than 250 bar litres then the following PSSR requirements do not apply:

- 5(4) - Marking of Vessels,
- 8 - Written Scheme of Examination
- 9 - Examination in accordance with the written scheme
- 10 – Action in case of imminent danger and
- 14 - Keeping of records

Where the system is within the scope of the PSSR the user shall not allow it to be used without a written scheme of examination prepared by a competent person in accordance with the regulations and shall ensure its periodic examination as required by the scheme. Other regulations such as the Provision and Use of Work Equipment Regulations (PUWER) also require users to ensure systems are properly maintained in good repair so as to prevent danger.

The inspection and maintenance schedule shall also take account of the specific recommendations for the system components to be found in the appropriate instruction manuals.

The frequency of the maintenance activity will depend on the type, size, quality, age and application of the system, the environment in which the system is located and the effectiveness of previous maintenance.

It is recommended that particular attention is given to systems in the period immediately following major alterations, major service or breakdown work, change of refrigerant or start up following any prolonged period of non-operation.

Routine inspection of equipment can indicate potential failures and allow a planned response. They also help to minimise ammonia loss and should be carried out at appropriate intervals by the competent operating staff of attended systems. Non-attended systems should be subject to regular planned minor maintenance inspections by competent, qualified persons.

A more extensive major planned maintenance inspection should be carried out at least once a year, also by suitably competent, qualified persons.

For larger systems, attention to components such as compressors could be related to periods of use in terms of hours run, in which case the manufacturer’s recommendations in the appropriate instruction manual should be followed.
The provision of the necessary personal protective equipment, first aid and safety equipment as detailed in appendix G of this Code shall be ensured before service and maintenance work is carried out. A respirator suitable for use with ammonia (see BS EN 529:2005 Respiratory protective devices) shall be worn or immediately available.

7.2 System Log

Where appropriate, manual or automatic data records should be kept. These should be made available for local or remote interrogation. They are important in aiding fault finding and establishing system behaviour during normal operating conditions, over varying duties and variations in ambient conditions. Systems designed for unmanned operation under automatic control should incorporate automatic data recording and local and remote fault annunciation. This database should be interrogated at regular intervals such as identified in appendix H of this Code.

Records of the use of consumables such as type and quantity of refrigerant and oil added to or removed from the system shall be retained on site in a safe place for a minimum of 5 years and regularly scrutinised by a competent person. See also section 8.6 of this Code.

The recommendations in the IOR Code of Practice for the Minimisation of Refrigerant Emissions should be followed where appropriate, and urgent action taken to investigate leakage of ammonia or oil.

The items recommended for inclusion in system logs are shown in appendices I and J. However the format and content used for automatic recording systems will be dependent on the design specification of the control and logging equipment. See also Section 5.4 of the Institute of Refrigeration’s Code of Practice for Minimisation of Refrigerant Emissions.

7.3 Routine Inspection

7.3.1 General

It is the duty of all users of refrigeration to ensure that they operate safe, energy efficient and environmentally acceptable systems.

The recommendations given in the IOR Code of Practice for the Minimisation of Refrigerant Emissions should be followed and due notice should be taken of the users’ responsibilities detailed in section 5.3 of that code.

For all systems, the ammonia charge should be recorded in the system log or register. The method of checking the ammonia charge will depend on the system design and in most applications the ammonia level in storage receivers will vary according to the evaporator load and ambient conditions.

Any oil analysis results should form part of the operating records. If excessive moisture is found, appropriate action shall be taken. Great care should be taken to ensure that the sample itself is not contaminated during handling.

Checks should also be made for the correct operation and control of all ancillary equipment including fans and pumps where applicable.

Systems should be assessed and investigated where appropriate in relation to incorrect ammonia liquid level
Excessive noise or vibration, build-up of frost or ice, restricted air or water and/or secondary refrigerant flow and liquid level should be assessed and remedial action shall be taken where appropriate.

Oil shall be drained from systems in accordance with established procedure such as BS EN 378-4:2016 Annex A.

7.3.2 Logging system performance

The system performance record under full and varying load conditions should be recorded over a period and made available to operatives and remote interrogators.

The master record may be compiled for seasonal weather conditions supplemented with data from commissioning and/or service and maintenance activities.

If any significant departure from expected conditions or performance is identified whilst completing logs or during remote interrogation, appropriate corrective measures shall be implemented promptly.

7.3.3 Pipework

The system pipework should be visually examined for evidence of any condition which could give rise to failure, including damage, wear, vibration, poor jointing, inadequate support and exposure to damage from adjacent activities.

Particular attention should be paid to high-pressure pipework, especially associated with compressors, where failure could place operatives in danger and/or result in serious ammonia loss.

The causes of such conditions should be identified and appropriate action taken to rectify the fault.

Damage to pipework insulation and, where applicable, the vapour seal, should be rectified without delay after any resultant corrosion has been treated.

The operation of trace heaters should be checked. Trace heaters which are vulnerable to damage should be suitably protected.

7.3.4 Compressors

The oil control system including oil separators and reservoirs should be examined for correct functioning, including oil levels and temperatures, which should be in accordance with the manufacturer’s recommendations.

Oil return reservoir operating pressures should be checked, particularly for over-pressure. Compressor gauges, pressure transducers and other transmitters should be checked and recalibrated as necessary. Safety and Control devices should be checked for correct settings and operation and adjusted where necessary.

Care should be taken to identify the type of oil recommended by the manufacturer for the system, and compared with that retained in the plant room and labelled for service purposes. It should be safely handled when added to or taken from a system and only used from a sealed container. All
used oil shall be disposed of in accordance with current waste legislation (Hazardous Waste Regulations).

Particular care should be taken with the storage and use of hygroscopic oils.

The extent of oil use should be examined and a reference made to the log (or register) retained in the plant room. Shaft seals on open drive compressors should be checked for significant oil leaks and for refrigerant leaks.

Any requirement to add oil regularly to an established system shall be thoroughly investigated and the cause identified. Excessive oil may impair system performance and damage compressors.

Compressors should additionally be checked for effective operation particularly during part load operation.

If an electric drive motor has been replaced a thorough check of the electrical contactors’ should be made. They should be replaced if evidence of burning is found.

Compressors incorporating liquid refrigerant injection for discharge temperature control should be examined for correct operation and in particular for excessive liquid injection.

Valve stem glands on service valves should be checked for leakage and valve caps should be checked to ensure the cap seal is in place.

The examination of compressors should include a check of all operating conditions against the log and the optimum recorded conditions (see section 7.3.1 of this Code.).

7.3.5 Condensers and Evaporators

The air-on surface of forced air coolers, condensers and cooling towers should be examined for contamination and obstruction. Where appropriate, steam or proprietary fluid cleaning by specialists should be arranged to coincide with the maintenance work to minimise interference with normal operation.

Note: Care should be taken in the selection of the cleaning fluid to avoid damage to the heat exchanger.

Internal air baffles or deflectors should be checked for obstruction together with a general examination of the headers, local piping and de-superheaters if fitted. Where installed, air inlet filters should be checked for cleanliness and correct fitting.

Motorised dampers and associated controls should be checked for correct response and operation.

Evidence of deterioration due to weathering of casings, supports and fan guards should be noted including a check for correct levelling to avoid inhibiting liquid draining. Where appropriate, remedial action should be taken.

Fan operating sequence and pressures should be checked together with the effectiveness of the air distribution during part load operation. Fan belt tension should be checked and any indication of excessive wear investigated.
The use of cooling water either in evaporative condensers or cooling towers entails a statutory requirement for an appropriate water treatment regime. Sampling tests shall be undertaken to monitor bacteria levels and other water quality parameters. Remedial action shall be carried out if necessary and details recorded. Refer to HSE Legionnaires’ disease, the Control of Legionella Bacteria in water systems, Approved Code of Practice L8. HSG274 Technical Guidance Part 1 The Control of Legionella Bacteria in Evaporative Cooling Systems recommends that at least every six months the cooling water system shall be drained, cleaned and disinfected using appropriate treatment recommended by water treatment specialists. It is a statutory requirement to preserve a written record of this treatment.

Water pump glands and line filters should be checked and the correct operating and changeover sequence tested to the specification in the system manual.

The water bleeds from evaporative condensers and cooling towers shall be checked and adjusted as required and attention given to ensure correct function of water treatment processes employed to combat scale, corrosion and bacterial or fungal activity.

Checks should be made for the presence of non-condensable gases in condensers. The presence of large quantities of non-condensable gases could indicate a leak on the low-pressure side of the system or inadequate system evacuation. The plant log should be examined to identify any evidence of maintenance activity or system breakdown which may have contributed to the ingress of air, and if appropriate the low side should be isolated and tested for leaks.

Non-condensable gases can be purged to atmosphere from the condenser. Care shall be taken to minimise the release of ammonia. If an automatic refrigerated purger is not installed then a temporary mechanical device may be fitted for this purpose.

Inspections should also include the external appearance of the surface of uninsulated vessels and heat exchangers. If the vapour barrier which has been applied to insulated vessels and heat exchangers is in good condition and shows no signs of ice or condensation then the vapour barrier should not be disturbed, as the underlying surface of the vessel can be presumed to be in good condition. If a core sample of the insulation is removed to inspect the vessel then care shall be taken to ensure that the vapour barrier is properly reinstated. The findings shall be recorded in the log.

Air cooling coils or grids and defrost water drains should be examined for blockages, frost build-up or ice accumulation and appropriate action taken.

The settings of automatic defrost controls should also be checked against the instruction manual requirements or commissioning data and a check made of the plant log for any changes that have been made.

7.3.6 Liquid Pumps

Pumps protected by line filters should be checked for obstructions which may reduce the liquid flow and cause unnecessary noise and vibration. Such filters should be removed and cleaned if deterioration in performance is apparent.

Control of lead and standby pumps should be checked for correct operating sequence as specified in the instruction manual.
7.3.7 Pressure Relief Devices and Pressure Controls

The PSSR examination requirements call for systems to have correctly set and labelled pressure relief and protection devices.

Pressure relief valves should be examined for signs of prior operation and leakage.

Routine preventative maintenance shall include a thorough check of these devices by competent persons. Any discrepancies shall be remedied.

All protective devices shall be provided with unique identification, preferably by affixed labels, to ensure satisfactory management of inspection and maintenance routines. Where identification has not been fitted by the installer this shall be provided during initial maintenance.

Automatic control valves and other control devices generally have no external moving parts, therefore any inspection may be limited to a check for correct functioning and setting, damage and ammonia or oil leakage at the connections to the system.

7.4 Major Inspection

Systems and components may require a more detailed inspection than is possible during normal operation. These inspections shall be carried out at least once a year and shall meet the requirements of this section and the instruction manual. The Major Inspection shall include items listed under Routine Inspection (section 7.3 of this Code).

Prior to a Major Inspection the system log (or register) and service record shall be examined to evaluate the behaviour of the plant since the last Major Inspection (see Appendix H and Appendix I).

For equipment which has operated on an intermittent basis or which has been temporarily out of use the frequency of detailed external inspection should be modified to account for possible deterioration at an accelerated rate during shut down. Any additional examination should consider external corrosion due to damp insulation, internal corrosion from the presence of air or water, fouling of heat exchanger surfaces due to stagnant liquids, or other fluid levels below normal.

A system that has not been operative for three months or more requires a Major Inspection and appropriate remedial works prior to returning it to operation. Evaporative cooling equipment will require thorough cleaning and flushing after any period of shutdown.

7.4.1 System

The reason for any large additions of ammonia or oil shall be investigated to ensure that proper corrective action has been taken.

All serviceable ammonia filters and strainers should be cleaned and inspected for damage.

Heat transfer liquids such as brine, glycol, silicone-based oils and other secondary refrigerants shall be checked. This check should include concentration, pH, moisture content and contamination. Appropriate remedial action shall be taken where necessary.

7.4.2 Pipework

Low temperature insulated pipework particularly that which cycles though 0°C, shall be thoroughly
inspected for any external damage. Condensation or frosting on the surface may indicate a deterioration or breakdown of the insulation or vapour barrier. Attention shall be paid to valve stations, reverse cycle systems and pipework emerging from insulation such as stubs for oil draining.

In such instances repairs shall be carried out without delay to minimise ingress of moisture. Sections of insulation which are obviously in poor condition shall be removed and the resultant exposed pipework protected as appropriate before reinstating insulation and vapour seal.

All exposed pipework and associated components such as flanges and supports shall be inspected for any damage or deterioration to the protective finish and remedial action taken where necessary.

Pitting or loss of metal, where considered by subjective assessment to be serious, should be checked accurately using techniques such as ultrasonic measurement.

Routine inspection of pipework under undamaged thermal insulation and vapour seal is not necessary.

Where pipework is repaired or replaced particular care should be taken to ensure that the piping material used is appropriate for the lowest working temperature and the maximum allowable pressure (PS) of that part of the system.

Where pipework is repaired or replaced any welding or jointing shall be to the appropriate standard as indicated in 4.2 of this Code.

7.4.3 Compressors

The interval between compressor inspections and maintenance involving an internal examination should follow the manufacturer’s recommendations especially with regard to replacement of components. This inspection should preferably be timed to coincide with the cleaning or replacement of oil filters or an oil change if appropriate.

The compressor manufacturer’s recommendations with respect to routine mechanical and electrical inspection and maintenance, including checking electrical connections, mechanical drive, and required compressor component replacement, should be followed. Only competent, trained persons suitably skilled to service the appropriate compressors shall be engaged in such maintenance.

At least every twelve months, or earlier if stipulated by the manufacturer, open drive compressor motors shall be electrically isolated, locked off and inspected mechanically and electrically in accordance with the manufacturer’s instructions. Bearings should be greased according to the manufacturer’s recommendations.

The drive alignment including compressor and driver end float should be checked.

The torque applied to the holding down bolts for the compressor and driver should be checked and discrepancies rectified.

Where a belt drive is employed the condition of the belts should be examined and the alignment and tension checked as recommended for routine maintenance and in accordance with the manufacturer’s instructions.

The starting sequence of the compressor should be proved. This includes motors designed for direct
on-line, part-wind, or star-delta starting where the starting sequence, together with timers, should be checked for correct operation.

Electrical connections shall be checked for correct tightening torque including all earthing connections. Electrical safety components such as overloads should be checked against the operating instructions. Thermography is a useful technique for identifying overheating.

Special attention should be paid to intermediate pressure parts in a two stage system that may be subjected to excess loading due to high pressure during start-up and pull-down.

Components that might suffer fatigue, such as connecting rod bolts in reciprocating compressors, should be destroyed when they have reached the manufacturer’s recommended life to prevent reuse.

The cooling jackets of water-cooled compressors and oil cooling heat exchangers (see also section 7.4.4 of this Code.) should be examined for corrosion and to ensure that fouling has not reduced the heat transfer capability.

The complete compressor unit, vessel or heat exchanger shall be isolated from the system before undertaking any work.

Any elements containing ammonia shall be isolated and evacuated before opening to atmosphere and before draining oil.

After inspection and overhaul, the compressor must be recharged with oil of the recommended grade and evacuated in accordance with Appendix E4 of this Code.

7.4.4 Pressure Vessels and Heat Exchangers

This section covers inspection of pressure vessels (with or without internal coils), shell and tube heat exchangers, extended surface air coolers or condensers, cooling towers and coil, grid or plate heat exchangers and refrigerant cooled oil coolers.

The frequency and type of inspection of pressure vessels and heat exchangers will vary with the application and location of individual systems. An increased frequency of inspections may be required for the following cases:

a. The recommissioning of an installation.
b. Corrosive or adverse environmental conditions.
c. Information derived from current service conditions on the system or on similar systems.
d. Possible adverse effects of cyclic loading.
e. Possible effects of local changes

As indicated under routine maintenance it is not expected that the surface of vessels with undamaged thermal insulation and vapour seal will need be inspected. Where the insulation is obviously in poor condition through damage or age, arrangements should be made for its replacement.

Areas affected by slight corrosion should be cleaned off and appropriately treated before reinstatement of the protective finish, insulation and vapour barrier. Heavy pitting or loss of metal should be checked accurately by using techniques such as ultrasonic measurements.
Water cooled condensers and evaporative condensers should be checked for fouling on the water side and cleaned in accordance with manufacturer’s instructions.

Cooling towers should be checked for obstructions to water and airflow and where necessary the water distribution system cleaned and the packing flushed or replaced if damaged and a written record kept of these actions. The use of cooling water in either evaporative condensers or cooling towers requires an appropriate water treatment regime. Sampling tests shall be undertaken to monitor bacterial levels and other water quality parameters. Remedial action shall be carried out if necessary and detailed records kept. Refer to HSE ACOP L8 and HSG274 Technical Guidance Part 1.

Inspection of the system log may indicate progressive fouling. Cleaning should be programmed for periods of light system load eg before the summer.

HSG274 Technical Guidance Part 1 The Control of Legionella Bacteria in Evaporative Cooling Systems recommends that at least every six months the cooling water system shall be drained, cleaned and disinfected using appropriate treatment recommended by water treatment specialists. It is a statutory requirement to preserve a written record of this treatment.

Cooling tower fan impellers and mountings should be inspected for signs of fatigue fractures, insecure mountings and heavy corrosion. All fan guards should be inspected to ensure their integrity.

Frost protection elements should be tested electrically for correct operation.

Correct direction of pump and fan rotation and of airflow should be confirmed after any hard wired reconnection to the electrical supply.

7.4.5 Refrigerant Pumps

Liquid ammonia pumps operating at sub-zero temperatures, particularly where not insulated, will become covered with a layer of dense ice which prevents corrosion of the main body of construction materials. However, at the limits of the ice, corrosion may occur if the paint layer becomes broken and these areas should be carefully examined. If corrosion is excessive the pump should be shut down to allow the ice thaw so that the points of corrosion can be cleaned and repainted or the pipe replaced. Vent lines should also be inspected externally for corrosion.

End covers of centrifugal pumps should be removed and impellers and bearings inspected in accordance with manufacturers’ instructions.

After any disconnection of the electrical supply to a pump or to the system as a whole the correct direction of rotation of the pump shall be verified on reconnection.

7.4.6 Stop Valves, Safety Valves and Control Devices

Any valve with an exposed spindle should have the condition of the spindle and the gland seal inspected and if necessary the spindle cleaned and protected.

Valves that are normally open should be moved off the back-seated (fully open) position as part of the inspection to subject the gland seal to ammonia pressure. Seals should be inspected for leakage and repaired if necessary. After the inspection ensure valves which are normally back-seated are returned to the back-seated position.

Extra caution should be exercised when inspecting and operating valves not in regular use; defective
seals can lead to sudden and violent leakage.

Seals should be replaced at the intervals recommended by the valve manufacturer.

Where valve spindles are capped, the valve cap shall be removed and the condition of the spindle and gland seal checked as in the preceding paragraphs. The joint ring shall be in place and any pressure-relieving vents shall be unobstructed before the cap is replaced.

On uninsulated valves the hand wheels, flange securing bolts and valve cover (bonnet) bolts shall be inspected and defects due to damage or corrosion shall be rectified. Bodies and bolts of insulated valves shall be inspected as part of the associated piping examination covered in section 7.4.2 of this Code.

Most automatic control valves have no external moving parts requiring maintenance and should only be dismantled and overhauled at the intervals recommended by their manufacturer or when found faulty in service. Filters installed upstream of control valves should be inspected and cleaned.

Automatic valve operation may be checked by changing the setting of the controlling device and observing the response.

Extreme care should be exercised to avoid producing conditions that could cause damage to other parts of the system. Any setting changes must be reinstated to the appropriate value and the normal function verified.

Operatives have a responsibility to exercise appropriate precautions to avoid hazard from released pressure energy from trapped residual ammonia when, for example, filters are opened or control valves dismantled.

Liquid ammonia may be trapped in assemblies that have become corroded or choked with foreign matter.

Pressure relief devices shall be visually inspected for date of installation, correct relief setting, flow details, correct size and ammonia compatibility. Lack of these details, or visible damage to the valve, shall result in the valve being replaced.

Vent lines, including common vent lines, shall be inspected and proven to ensure that they are clear. Vent lines shall discharge to a safe place and shall be protected against ingress of moisture, which could freeze and restrict discharge. Vent lines or relief valves should incorporate a means of indicating that a valve has lifted then reseated. When a safety valve is removed from a common discharge line shared with other safety valves, the open connection to the discharge line shall be blanked off until the valve is replaced.

Pressure relief devices that vent to the low-pressure side are not generally subject to corrosion problems but must also meet the above requirements.

Bursting discs and the majority of pressure relief valves cannot be tested without using a purpose built rig. Should there be any doubt regarding a valve or cartridge suitability, it shall be replaced.

At least every five years relief valves and cartridges shall be removed for retest or replacement as applicable. At least every five years all high side and low side bursting discs shall be replaced. However, compressor internal relief valves that vent to the low pressure side need not be examined and tested except as recommended by the compressor manufacturer.
All replacement pressure relief devices shall be correctly selected and set for the appropriate maximum allowable pressure as shown in Appendix B of this Code. Details of such replacement shall be noted in the system register and the date of change identified on the pressure relief device label. Care shall be taken to ensure that the label remains legible.

Pressure, temperature and level sensors shall be tested and serviced according to the manufacturer’s instructions.

The correct functioning of safety switches shall be tested. Pressure gauges used in the testing of any safety switches shall be calibrated. Procedures for testing are given in Appendix E5 of this Code. Failure to comply with the above could contravene the PSSR.

### 7.5 Pressure System Examination

#### 7.5.1 General

The requirements for regular re-examination of pressure systems to ensure safe operation are laid down in PSSR. There may be additional requirements relating to other safety considerations in other legislation, for example release of refrigerant through relief valves would be within scope of Provision and Use of Work Equipment Regulations (PUWER).

Where additional inspection is required or a system is not within the scope of the PSSR and a written scheme of examination is not applicable an independent inspector may be appointed to establish the system’s condition. In this Section of this Code, the term ‘Inspector’ means either the independent inspector or competent person as applicable.

The Inspector shall fulfil the requirements of the PSSR and may also carry out whatever examinations and tests are considered necessary in order to be satisfied regarding the condition of the equipment. Where necessary the Inspector shall specify any repairs or adjustments required to ensure the safety of the system and stipulate a date by which they should be completed and/or allocate new safe operating limits to the system.

Special attention should be paid to possible deterioration of areas around supports and attachments to vessels especially those operating below the dew point of the surrounding air. Inspection of heat exchangers should include tubes and tube plates where required by the Inspector.

The method and extent of any testing shall be determined by the Inspector who must take into account any relevant regulations, standards and codes applicable at the time of inspection. Guidance is given below on the typical extent and limits of testing envisaged.

#### 7.5.2 Uninsulated Vessels and Heat Exchangers

Uninsulated vessels and heat exchangers shall be given a thorough visual examination supplemented where appropriate by additional non-destructive inspection techniques.

Where there is no indication that the mechanical integrity of the vessel or heat exchanger has deteriorated since installation or since the last Pressure System Examination and where the maximum allowable pressure for the vessel is clearly recorded together with evidence of an earlier strength pressure test, no further testing is necessary.
Where corrosion is found, the Inspector shall determine whether the vessel can be put back into service after it has been cleaned and repainted to limit further deterioration.

Where external corrosion has significantly reduced the component thickness the Inspector shall have the area examined and shall check that the remaining thickness is within the minimum required by the original specification. If the corrosion has reduced the thickness below the minimum required the item shall either be scrapped, repaired if appropriate or assigned reduced operating limits accordingly.

Vessels of unknown origin shall be scrapped or subject to an assessment by a competent person, which may include a strength test. Severely corroded vessels shall be subject to assessment by a competent person which may include non-destructive testing before a repeat strength pressure test is carried out.

If the vessel is accepted as suitable for further use records of the non-destructive testing and of the strength pressure testing shall be recorded in the system register.

If a vessel or heat exchanger has been subjected to a major repair or alteration or if adequate visual inspection is not possible the vessel shall be subjected to non-destructive testing followed by a strength pressure test which shall be recorded in the system register.

The conditions that would allow a pneumatic pressure test to be carried out are given in Appendix C of this Code.

If a hydraulic test is required, it shall be confirmed that the vessel supports and building structure are adequate for the additional weight of the liquid. Attention should be given to potential operating difficulties if all the liquid cannot be removed after the test.

7.5.3 Insulated Vessels and Heat Exchangers

Special considerations arise in connection with insulated vessels and heat exchangers because inspection without removal of insulation is usually not possible. Partial removal and replacement of insulation can often impair the vapour seal and hence reduce resistance to corrosion.

Insulated vessels operating permanently at temperatures below 0°C and with undamaged insulation and vapour seal are unlikely to be corroded.

The Inspector shall fulfil the requirements of the PSSR and PUWER and may also carry out further examinations.

The Inspector may, at their discretion, waive further inspection of the vessel until the next major inspection provided full records are available, visual inspection shows insulation and vapour seals are undamaged and the insulation has not been significantly repaired or replaced since the last Pressure System Examination. Thermal imaging may be used to view the integrity of the insulation.

At any major repair or renewal of the insulation the opportunity shall be taken to examine the vessel for external corrosion and the vessel surface shall be suitably protected before being re-insulated. No attempt shall be made to protect and re-insulate a vessel while the surfaces are wet or frosted.

Where branches on low temperature vessels are beyond the insulation line and may attract condensation deterioration is more likely and the degree and frequency of inspection shall take this
into account.

Where the insulation or vapour barrier is damaged an inspection of the underlying vessel or heat exchanger shall be carried out.

If the vessel strength has not been significantly affected as defined in 7.5.2 of this Code, any areas of corrosion shall be cleaned and protected before the vessel is re-insulated.

If, in the opinion of the Inspector, the strength of the vessel has been affected then non-destructive testing of the vessel shall be carried out. If the non-destructive testing of the vessel is satisfactory then a strength pressure test shall be carried out as described in Appendix C of this Code. If the vessel is accepted as suitable for further use then records of the non-destructive testing and of the strength pressure testing shall be kept in the system register.

Heat exchangers or pressure vessels operating at temperatures above 0°C, such as water chillers with ammonia in the shell, may be subject to corrosion depending on the type of insulation.

7.5.4 Extended Surface Heat Exchangers and Grid Coils

For most applications galvanised steel or stainless materials are used.

Extended surface heat exchangers and grid coils shall be examined as for pipework in Section 7.4.2 of this Code.

Coils and pipes which are provided with gas defrost are subjected to rapid pressure and temperature changes and may be subject to high stresses. In such cases it is at the discretion of the Inspector to require non-destructive testing or replacement of the component. The Inspector should check that arrangements to prevent liquid hammer at initiation and termination of hot gas defrost are functioning correctly.

7.5.5 Plate Heat Exchangers

For most applications stainless materials are used. The strength of such heat exchangers should not deteriorate with time and risk to personnel caused by a failure is negligible. Where contaminants such as chlorides and acids are present pinhole corrosion may take place.

Unless there is obvious damage or corrosion that can significantly reduce the pressure integrity of the ammonia passages no further pressure testing is necessary, with the exceptions listed under 7.5.6 of this Code.

7.5.6 Piping

Insulated and uninsulated piping shall be visually inspected for corrosion and condition of vapour seals by the Inspector. Non-destructive testing shall be carried out if appropriate.

7.5.7 Pressure Test for Strength

Pressure vessels, heat exchangers and piping should not be subject to regular periodic tests to the strength test pressure. Such tests shall be carried out when:

- Statutory regulations make it mandatory,
- The pressure integrity may have been affected by corrosion,
A hydraulic test is necessary in lieu of other forms of inspection and non-destructive testing,
The maximum working pressure has to be increased,
Repairs or modifications have been made and the strength must be re-verified.

The strength test shall then be followed by a tightness test.

7.5.8 Extent of Tightness Test

If tightness tests are required then they shall be arranged so that all parts of the vessel or heat exchanger which form part of the ammonia circuit are exposed to the appropriate tightness test pressure. See Appendix C of this Code.

Precautions shall be taken to ensure that leakage to other chambers of the vessel or heat exchanger cannot remain undetected or that those chambers shall not be pressurised beyond their maximum allowable pressure.

Precautions shall also be taken to avoid subjecting other parts of the ammonia circuit to the tightness test pressure.
Section 8 - Documentation

8.1 General

Documentation for the refrigerating system shall be provided to meet statutory regulations such as a declaration of conformity as required by the Pressure Equipment (Safety) Regulations 2016 (PER). Documentation shall also give essential information on the safe operation and maintenance of the installation. Details of particular documentation which may be required are given below. It should be noted that specialist input might be required in compiling some of the particular items. Original documentation required may be kept in the user’s filing system but a duplicate shall be kept within easy access of the refrigerating system and shall be made readily available to any organisations or personnel with responsibilities with respect to the system.

Documentation shall be updated as appropriate and responsibilities for this duty and for the general management of the documentation shall be clearly allocated.

8.2 Risk Assessment

To meet the requirements of the Management of Health and Safety at Work Regulations 1999, the user of a refrigerating system must include this plant in the workplace risk assessment. In general terms, the risk assessment must identify the significant hazards associated with the system and measures to minimise and control the risk to any persons likely to be affected. The risk assessment shall be recorded formally, reviewed as a regular management exercise and updated as appropriate.


8.3 Health and Safety File

Where the construction of a refrigerating system comes within the scope of the Construction (Design and Management) Regulations (2015), the Principal Contractor has a statutory duty to prepare a Health and Safety File for the system and to deliver this to the client. Where the installation is outside the scope of the Regulations, the client may still require a Health and Safety File to be provided. The Regulations place duties on various parties to contribute to the file, including clients, designers and installers.

The File content should concentrate on providing concise information to alert others to significant risks associated with the refrigerating systems which they cannot reasonably be expected to know.

The File may include drawings of the plant, the design criteria, general details of materials and construction methods used, maintenance facilities and procedures, manufacturers’ instruction manuals and emergency procedures.

Details of the requirements in respect of a Health and Safety File are given in Approved Code of Practice LS4, published by the Health and Safety Commission and in HSE Information Sheet, Construction Sheet No 44, Health and Safety File.

8.4 Written Scheme of Examination and Records

To meet the requirements of the PSSR (where applicable – see section 7.1 of this Code.), the user of
the refrigerating system shall produce a Written Scheme for the periodic examination, by a competent person, of parts of the system. The user may request the installation contractor to provide the initial Written Scheme or may employ a competent person to do so. The parts to be examined shall comprise the complete pressure-containing system including all protective devices and pressure vessels and any pipelines or pipework in which a defect may give rise to danger.

The Written Scheme shall specify the frequency of examination and preparatory measures necessary prior to the examination. The user must ensure that the written scheme has been compiled, or certified as suitable, by a competent person and that it is reviewed at appropriate intervals and modified to meet any recommendation made by the competent person.

The written scheme shall be in place and the first inspection carried out before the plant is set to work.

The user shall retain the last examination report of the competent person, any previous reports with particular relevance to the safety of the system and any agreement made regarding postponement of an examination.

Details of the requirements for the Written Scheme and keeping of records are given in the Approved Code of Practice and Guidance (L122) published by the Health and Safety Executive.

8.5 Commissioning Records

Typically the commissioning of a refrigerating system is carried out by the manufacturer or supplier.

Commissioning data recorded should include, but not be limited to, the following:

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

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

8.6 Refrigerant Inventory Record

A record should be maintained by the user of the refrigerating system of all ammonia used throughout the life of the plant.

The record should start with full details of the initial ammonia charge and cover particulars of any addition or removal of ammonia from the system. Details should include the source of supply of ammonia, the cause of ammonia loss and remedial actions taken.

Where any ammonia is removed details of the reasons for this should be recorded (e.g. the cause of contamination) together with the means of disposal. In effect, the record should provide an audit
trail of all ammonia throughout the life of the plant, from initial charging to final disposal.

8.7 Contingency Provisions

The user of the refrigeration system shall provide written procedures for the safe shutdown of the system under emergency conditions or other contingencies. The installation contractor may be instructed to provide these written procedures as part of the contract for the supply of the system.

The user shall ensure that appropriate personnel are made responsible for applying the contingency procedures and are given instruction and training on carrying out the procedures. Such training should include hands-on or simulated application of the procedures and should not be confined to verbal or written instruction. The user shall ensure that instruction is repeated when new staff are appointed to this role.

8.8 The System Register

The system supplier shall provide a system register containing all essential records and documentation relevant to the system for the user. It should be maintained by the user in a safe place and should be readily available for examination, so that the standards and details to which the system was designed and commissioned are available to those concerned with inspection and maintenance.

For all systems covered by this Code the system register shall contain a record of the maximum allowable pressure applicable to all parts of the system and of test and commissioning data including lubricant and ammonia charges.

The system register shall be kept up to date with reports covering at least the mandatory inspections and safety device checks and replacements called for in this Code and in any statutory regulations.

The system register may form part of a broader set of records for the refrigerating system eg the Instruction Manual (see section 8.10), System Log (see section 8.9), planned maintenance scheme etc. The planned maintenance records shall contain a schematic refrigeration circuit or flow diagram for the refrigerating system and a comprehensive wiring diagram. Controls and valves which are most likely to be of importance in an emergency shall be clearly identified on the flow diagram. It shall be updated when changes are made to the system.

For systems of total installed power input of less than 25kW the system register may be restricted to the manufacturer’s details of equipment.

For systems of total installed power input of 25kW or greater the system register shall include a general description of the system and specification with the following details as a minimum.

(a) Compressors
   Description
   Name Plate Data as in Appendix D
   Test Certificates
   Pressure relief devices, type and set pressure, date of installation/replacement

(b) Condensers
   Description
   Name Plate Data
Test Certificates
Pressure relief devices, type and set pressure, and date of installation/replacement

(c) Evaporators
Description
Name Plate Data
Test Certificates
Pressure relief devices, type and set pressure, and date of installation/replacement

(d) Pressure Vessels (see Appendix H)
Description
Name Plate Data as in Appendix D
Test Certificates
Pressure relief devices, type and set pressure and date of installation/replacement
Non-destructive examination report

(e) Pipework and Fittings
Description and Material(s)
Standard(s)
Welding Code
Test Certificate
Year of Construction
Design Pressure
Pressure test certificates
Non-destructive examination report

(f) Control and Safety Devices not listed above
Description
Settings
Test Data
Replacement/recalibration intervals.

Note 1: The requirements of the PSSR must be complied with for systems of total installed power greater than 25 kW. This Code requires some documentation in excess of that required by the PSSR.
Note 2: Manufacturers’ test certificates may be type test certificates.
Note 3: For details of the Health and Safety File refer to Section 8.3 of this Code.

8.9 System Log

The user shall maintain a system log as described in section 7.2 of this Code and shall keep records and commissioning logs for the life of the plant.

8.10 Instruction Manuals

The contents of the Instruction Manual are detailed in BS EN 378 -2:2016 Section 6.4.3.2 and include the following:

- The purpose of the system
- The description of the machinery and equipment
- Refrigerating system schematic diagram and electrical circuit diagram
- Instructions concerning starting, stopping and stand still of the system
- Instructions concerning the disposal of operating fluid and equipment
• Instructions concerning leakage detecting
• Precautions to be taken to prevent freezing of water in condensers or coolers
• Precautions to be taken when lifting or transporting systems or parts of systems
• On site information
• Emergency measures
• Maintenance instructions
• Instructions concerning charging and discharging of refrigerants
• Instructions concerning safe handling of refrigerants
• Safety, protective and first aid equipment and alarm devices
• Instructions to avoid over pressure during use, maintenance and servicing
• Information concerning noise emission
• Requirements for PPE
• Instructions for draining oil
• Emergency procedures
Section 9 - Decommissioning

9.1 General

The decommissioning procedure shall ensure that:

a. hazards to the operatives carrying out the process are minimised,

b. ammonia and oil are correctly recovered for reclaim or correct disposal,

c. the system does not present any further hazard to personnel or to the environment due to residual contents after decommissioning.

When a refrigerating system is to be decommissioned, taken out of use and dismantled or sold intact the user who no longer requires the system shall ensure that:

- Either the decommissioned system is leak-tight so that there is very little risk of leakage during storage and the new user of the system or the dismantler/disposer of the system is made aware in writing of the type and quantity of ammonia and oil contained within it and is fully conversant with the legal and other requirements for its safe storage, handling and ultimate disposal.

- Or the system ammonia (and oil) charge is decanted and evacuated, and is disposed of properly prior to decommissioning, sale or dismantling.

Reference should be made to Construction (Design and Maintenance) Regulations and Hazardous Waste Regulations.

9.2 Recovered Refrigerant

9.2.1 General

Ammonia removal shall be carried out by competent persons working to a written procedure, using appropriate recovery equipment if required.

Ammonia should be dissolved in water or recovered into a recovery cylinder or road tanker dedicated for ammonia. Containers provided for the supply of new ammonia shall not be employed as containers for used ammonia without the prior written consent of their owners since this may lead to contamination of the containers. Further guidance is given in BS EN 378-4:2016 Annex C.4

The Hazardous Waste Regulations apply to all recovered refrigerant transferred from site.

9.2.2 Refrigerant Recovery

When ammonia is transferred from a system as liquid, the container shall display a warning that the ammonia may contain contaminants.

When ammonia is transferred from a system it should be understood that the originating ammonia circuit will retain contaminants (oil, water, and particulate matter). Care should be taken in the disposal of these contaminants.

Where ammonia is decanted from the system into a cylinder care shall be taken to ensure that the weight of refrigerant transferred does not exceed the safe limit for the cylinder.
9.2.3 Recovery for recycling to another system

If ammonia is to be transferred to another system without being fully reclaimed the owner/operator/user shall be notified in writing of the possibility of cross-contamination.

9.2.4 Recovery for reprocessing or disposal

Recovered ammonia shall be returned to the original supplier or to a similar organisation to be disposed of as Hazardous Waste through an organisation licensed for the disposal of Hazardous Waste. Water into which ammonia has been absorbed shall be treated as hazardous waste when it is removed from site.

For transport and storage purposes the suitable containers shall be appropriately labelled.

Ammonia containers shall not be stored where temperatures can exceed 45°C and should not be stored in a machinery room.
Section 10 – References, Standards and Legislation (all refrigerants)

Note: The following lists are common across all four IOR refrigerant type Safety Codes. Some of the references appearing here will not be relevant to Ammonia refrigerant.

**British, European and International Standards**

<table>
<thead>
<tr>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosive atmospheres. Material characteristics for gas and vapour</td>
<td>BS EN 60079-20-1:2010</td>
</tr>
<tr>
<td>classification. Test methods and data</td>
<td></td>
</tr>
<tr>
<td>Aluminium and aluminium alloys – chemical composition</td>
<td>ISO 209:2007</td>
</tr>
<tr>
<td>Butt-welding pipe fittings. Non alloy and ferritic alloy steels with</td>
<td>BS EN 10253-2:2007</td>
</tr>
<tr>
<td>specific inspection requirements</td>
<td></td>
</tr>
<tr>
<td>Compressors and vacuum pumps. Safety requirements. Air Compressors</td>
<td>BS EN 1012-1:2010</td>
</tr>
<tr>
<td>Copper and copper alloys seamless round copper tubes for air</td>
<td>BS EN 12735-1:2016</td>
</tr>
<tr>
<td>conditioning and refrigeration. Tube for piping systems</td>
<td></td>
</tr>
<tr>
<td>Design of fans working in potentially explosive atmospheres</td>
<td>BS EN 14986:2017</td>
</tr>
<tr>
<td>Explosion venting devices</td>
<td>BS EN 14797: 2006</td>
</tr>
<tr>
<td>Explosive atmospheres. Classification of areas. Explosive gas</td>
<td>BS EN 60079-10-1:2015</td>
</tr>
<tr>
<td>atmospheres</td>
<td></td>
</tr>
<tr>
<td>Explosive atmospheres. Electrical installations design, selection and</td>
<td>BS EN 60079-14:2014</td>
</tr>
<tr>
<td>erection</td>
<td></td>
</tr>
<tr>
<td>Explosive atmospheres. Equipment protection by type of protection</td>
<td>BS EN 60079-15:2010</td>
</tr>
<tr>
<td>&quot;n&quot;</td>
<td></td>
</tr>
<tr>
<td>Explosive atmospheres. Explosion prevention and protection. Basic</td>
<td>BS EN 1127-1:2011</td>
</tr>
<tr>
<td>concepts and methodology</td>
<td></td>
</tr>
<tr>
<td>atmospheres. Basic method and requirements</td>
<td></td>
</tr>
<tr>
<td>atmospheres. Non-electrical type of protection constructional safety</td>
<td></td>
</tr>
<tr>
<td>&quot;c&quot;, control of ignition sources &quot;b&quot;, liquid immersion &quot;k&quot;</td>
<td></td>
</tr>
<tr>
<td>Fire and explosion precautions at premises handling flammable gases,</td>
<td>BS 5908-2:2012</td>
</tr>
<tr>
<td>liquids and dusts. Guide to applicable standards and regulations</td>
<td></td>
</tr>
<tr>
<td>Fire extinguisher installations and equipment on premises.</td>
<td>BS 5306-4:2001 +A:2012</td>
</tr>
<tr>
<td>Specification for carbon dioxide</td>
<td></td>
</tr>
<tr>
<td>Guidance on Safe Use of Machinery</td>
<td>PD 5304:2014</td>
</tr>
<tr>
<td>requirements for refrigerating appliances, ice-cream appliances and</td>
<td></td>
</tr>
<tr>
<td>ice-makers</td>
<td></td>
</tr>
<tr>
<td>requirements for electrical heat pumps air-conditioners, and</td>
<td></td>
</tr>
<tr>
<td>dehumidifiers</td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>BS EN ISO 4414:2010</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>requirements for commercial refrigerating appliances with an</td>
<td></td>
</tr>
<tr>
<td>incorporated or remote refrigerant condensing unit or compressor</td>
<td></td>
</tr>
<tr>
<td>Metallic Industrial piping</td>
<td>BS EN 13480-1:2012</td>
</tr>
<tr>
<td>Methodology for the risk assessment of non-electrical equipment and</td>
<td>BS EN 15198:2007</td>
</tr>
<tr>
<td>components for intended use in potentially explosive atmospheres</td>
<td></td>
</tr>
<tr>
<td>Non-destructive testing of welds. Acceptance levels for radiographic</td>
<td>BS EN ISO 10675-1:2013</td>
</tr>
<tr>
<td>testing, steel, nickel, titanium and their alloys</td>
<td></td>
</tr>
<tr>
<td>Non-destructive testing of welds. Radiographic testing of Welds</td>
<td>BS EN ISO 17636-2:2013</td>
</tr>
<tr>
<td>Performances of portable leak detectors and of room monitors of</td>
<td>BS EN 14624:2012</td>
</tr>
<tr>
<td>halogenated refrigerants.</td>
<td></td>
</tr>
<tr>
<td>systems and their components (CD-ROM)</td>
<td></td>
</tr>
<tr>
<td>General requirements.</td>
<td></td>
</tr>
<tr>
<td>Vessels. General requirements.</td>
<td></td>
</tr>
<tr>
<td>Qualification testing of welders. Fusion welding. Steels</td>
<td>BS EN ISO 9606-1:2017</td>
</tr>
<tr>
<td>Refrigerants Designation and Safety Classification</td>
<td>BS EN ISO 817:2014</td>
</tr>
<tr>
<td>Vibration isolators, expansion joints and non-metallic tubes.</td>
<td></td>
</tr>
<tr>
<td>Refrigerating systems and heat pumps. Safety switching devices for</td>
<td>BS EN 12263:1999</td>
</tr>
<tr>
<td>limiting the pressure. Requirements and tests</td>
<td></td>
</tr>
<tr>
<td>Requirements, testing &amp; marking</td>
<td></td>
</tr>
<tr>
<td>Refrigerating systems and heat pumps. Pressure Relief Valves and</td>
<td>BS EN 13136:2013</td>
</tr>
<tr>
<td>their Associated piping. Methods for calculation.</td>
<td></td>
</tr>
<tr>
<td>Refrigerating systems and heat pumps. Safety and environmental</td>
<td>BS EN 12693:2008</td>
</tr>
<tr>
<td>requirements. Positive displacement refrigerant compressors.</td>
<td></td>
</tr>
<tr>
<td>Refrigerating systems and heat pumps. System flow diagrams and</td>
<td>BS EN 1861:1998</td>
</tr>
<tr>
<td>piping and instrument diagrams. Layout and symbols</td>
<td></td>
</tr>
<tr>
<td>and Marking</td>
<td></td>
</tr>
<tr>
<td>Refrigeration Systems and Heat Pumps. Environmental Requirements</td>
<td>BS EN 378:2016-1/2/3/4</td>
</tr>
<tr>
<td>Refrigerating systems and heat pumps. Qualification of tightness of</td>
<td>BS EN 16084:2011</td>
</tr>
<tr>
<td>components and joints</td>
<td></td>
</tr>
<tr>
<td>Requirements for electrical installations. IEE Wiring Regulations.</td>
<td>BS 7671:2008+A3:2015</td>
</tr>
<tr>
<td>Seventeenth Edition</td>
<td></td>
</tr>
<tr>
<td>Respiratory protection devices, recommendations and guidance</td>
<td>BS EN 529:2005</td>
</tr>
<tr>
<td>Safety Devices for Protection against excessive pressure</td>
<td>BS EN ISO 4126</td>
</tr>
<tr>
<td>their components. Pneumatics</td>
<td></td>
</tr>
<tr>
<td>Specification and qualification of welding procedures for metallic</td>
<td>BS EN ISO 15607:2003</td>
</tr>
<tr>
<td>materials. General rules</td>
<td></td>
</tr>
<tr>
<td>Specification for arc welding of austenitic stainless steel pipework</td>
<td>BS 4677:1984</td>
</tr>
<tr>
<td>for carrying fluids</td>
<td></td>
</tr>
<tr>
<td>Specification for Bolting for flanges and pressure containing</td>
<td>BS 4882:1990</td>
</tr>
<tr>
<td>purposes</td>
<td></td>
</tr>
<tr>
<td>Specification for Class I arc welding of ferritic steel pipework for carrying fluids</td>
<td>BS EN 2633:1987</td>
</tr>
<tr>
<td>Specification for Class II arc welding of carbon steel pipework for carrying fluids</td>
<td>BS 2971:1991</td>
</tr>
<tr>
<td>Specification for copper and copper alloy pressurised pipe systems</td>
<td>BS EN 1306:1975</td>
</tr>
<tr>
<td>Specification for identification of pipelines and services</td>
<td>BS 1710:2014</td>
</tr>
<tr>
<td>Specification for safety of household and similar electrical appliances. Particular requirements for motor-compressors.</td>
<td>BS EN 60335-2-34:2013</td>
</tr>
<tr>
<td>Specification for Unfired Fusion Welded Pressure Vessels</td>
<td>PD 5500:2015</td>
</tr>
<tr>
<td>Transportable Gas Containers: Specification for seamless steel gas containers of water capacity 0.5 L up to 15 L for special portable applications</td>
<td>BS 5045-7:2000</td>
</tr>
<tr>
<td>Unfired Pressure Vessels. Design</td>
<td>BS EN 13445</td>
</tr>
</tbody>
</table>

**Regulations, Directives, Legislation**

- Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Equipment Regulations 2009
- EC Directives 2006/8/EC and 1999/45/EC
- SI 2009/1348

- Chemicals (Hazard, Information and Packaging for Supply) (Amendment) Regulations 2008
- CLP 2009
- SI 1997/1713
- SI 2015/51

- Control of Substances Hazardous to Health Regulations (COSHH) (as amended) 2002
- SI 2002/2677 as amended by SI 2004/3386
- SI 2014/68/EU

- SI 2016/1154

- Environmental Permitting (England and Wales) Regulations 2016
- SI 1997/23/EC

- Environmental Protection Act 1990
- ADR 2015

- European Agreement Concerning the International Carriage of Dangerous Goods by Road
- EC Regulation 517/2014

- Fluorinated Greenhouse Gases Regulation
- SI 310/2015

- Hazardous Waste Regulations (England and Wales)
- SI 894/2005

- Health and Safety at Work Amendment Act 1974
- SI 1332/2007

- Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972
- SI 1972/917

- List of Waste (England) Regulations
- SI 2015/1673

- Management of Health and Safety at Work Regulations 2006

**Note:** Published May 2018
<table>
<thead>
<tr>
<th>Notification of Cooling Towers and Evaporative Condensers Regulations</th>
<th>SI 2225/1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Depleting Substances (Qualifications) Regulations</td>
<td>SI 2006/1510</td>
</tr>
<tr>
<td>Ozone Depleting Substances Regulations</td>
<td>SI 168/2015</td>
</tr>
<tr>
<td>Pollution Prevention and Control (England and Wales) (Amendment) and Connected Provisions Regulations 2004</td>
<td>SI 2004/3276</td>
</tr>
<tr>
<td>Pressure Equipment (Safety) Regulation (PER)</td>
<td>SI 2016/1105</td>
</tr>
<tr>
<td>Pressure Equipment Directive</td>
<td>SI 2014/68/EU</td>
</tr>
<tr>
<td>Pressure Equipment Regulations 1999</td>
<td>SI 1999/2001</td>
</tr>
<tr>
<td>Pressure Systems and Transportable Gas Containers Regulations 1989</td>
<td>SI 1989/2169</td>
</tr>
<tr>
<td>Pressure Systems Safety Regulations(PSSR)</td>
<td>SI 128/2000</td>
</tr>
<tr>
<td>Provision and Use of Work Equipment Regulations (PUWER)</td>
<td>SI 2306/1998</td>
</tr>
<tr>
<td>The Special Waste (Amendment) (England and Wales) Regulations 2001</td>
<td>SI 2001/3148</td>
</tr>
<tr>
<td>Transport of Dangerous Goods by Road (ADR) 2017</td>
<td></td>
</tr>
<tr>
<td>Transport Pressure Equipment Directive (TPED) 2001</td>
<td></td>
</tr>
<tr>
<td>Workplace (Health, Safety at Work) Regulations 1992</td>
<td></td>
</tr>
</tbody>
</table>

**Health and Safety Executive Guidance Documents**

| Confined Spaces. Brief Guide to Working Safely | INDG 258 |
| Construction (Design and Management) Regulations. | L153:2015 |
| Control of Legionella Bacteria in Water Systems. Approved Code of Practice | L8:2013 |
| Control of Substances Hazardous to Health Approved Code of Practice | L5:2013 |
| Dangerous substances and explosive atmospheres. | ACOP L138 |
| Legionella Disease Technical Guidance Part 1 | HSG274:2013 |
| Managing Health and Safety | HSG65:2013 |
| Safety of Pressure Systems, - Approved Code of Practice | L122:2014 |
| Safety Requirements for Pressure Testing Guidance Note | GS4:2012 |
| The pressure systems and transportable gas containers regulations 1989 OC308/13 | OC308/13 |
| Workplace Exposure Limits (COSHH 2002) | EH40: 2005 (amend 2011) |

**Industry Guidance & Codes of Practice**

<p>| Boiler and Pressure Vessel code Section VIII Division 1 Pressure Vessels (2017) - American Society of Mechanical Engineers (ASME) | |
| BRA Guide for Risk Assessments and Method Statements (RAMS) Issue 1 December 2011 - British Refrigeration Association (BRA) | |
| British Compressed Gases Association Guidance Note on the Storage of Gas Cylinders in the Workplace | GN 2 - Rev 5 – 2012. ISSN 0260-4809) |</p>
<table>
<thead>
<tr>
<th>Title</th>
<th>Author/Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code of Practice 7 - Storage of Full and Empty LPG Cylinders and Cartridges (February 2004) - Liquefied Petroleum Gas Association (LPGA)</td>
<td></td>
</tr>
<tr>
<td>Commissioning Code R Refrigerating Systems (2002) - Chartered Institution of Building Services Engineers (CIBSE)</td>
<td></td>
</tr>
<tr>
<td>Piping for refrigeration (2016) -American Society of Mechanical Engineers (ASME)</td>
<td>B 31.5- Section 5</td>
</tr>
<tr>
<td>Pre-Commission Cleaning of Pipework. Systems - Building Services Research and Information Association (BSRIA)</td>
<td>BG29/2012</td>
</tr>
<tr>
<td>Safe management of ammonia refrigeration systems – Food Storage and Distribution Federation FSDF</td>
<td></td>
</tr>
<tr>
<td>Specification for Jointing of Copper Pipework for Refrigeration Systems - British Refrigeration Association (BRA)</td>
<td></td>
</tr>
<tr>
<td>Standard Maintenance Specification for Building Services– The Building Engineering Services Association (BESA)</td>
<td>SFG 20</td>
</tr>
</tbody>
</table>
Appendix A - Definitions

The words and their meanings in the IOR Refrigerant Codes are generally compatible with those defined and used in BS EN 378-1:2016. The list of definitions below is common to all IOR Refrigerant Code and not all terms may be relevant to the use of ammonia refrigerant.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazed joint</td>
<td>A joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 450°C but less than the melting temperatures of the joined parts.</td>
</tr>
<tr>
<td>Cascade System</td>
<td>Two or more independent refrigeration circuits where the condenser of one circuit rejects heat directly to the evaporator of another.</td>
</tr>
<tr>
<td>Coil or grid heat exchanger</td>
<td>Component of the refrigerating system constructed from pipes or tubes suitably connected and serving as a heat exchanger (eg evaporator or condenser).</td>
</tr>
<tr>
<td>Commissioning</td>
<td>The setting to work and regulation of a completed installation from its final assembly stage to full working order to ensure safe and reliable operation at design conditions. This includes keeping a record of performance and the settings of controls and safety devices.</td>
</tr>
<tr>
<td>Competent Persons</td>
<td>Competence is the ability to perform satisfactorily and safely the activities related to the given task. Levels of competence are defined in BS EN13313:2010 Refrigeration Systems and Heat Pumps Competence of Personnel. Refer to PSSR for the legal definition of a competent person</td>
</tr>
<tr>
<td>Gas Cooler</td>
<td>A heat exchanger in a transcritical system in which supercritical refrigerant is cooled by removal of heat.</td>
</tr>
<tr>
<td>Header</td>
<td>A pipe or tube component of a refrigerating system to which several other pipes or tubes are connected.</td>
</tr>
<tr>
<td>Lower Flammability Limit (LFL)</td>
<td>Minimum concentration of refrigerant that is capable of propagating a flame within a homogeneous mixture of refrigerant and air.</td>
</tr>
<tr>
<td>Machinery room</td>
<td>Enclosed room or space, with mechanical ventilation, sealed from the public areas and not accessible to the public, which is intended to contain components of the refrigerating system.</td>
</tr>
<tr>
<td>Non-condensables</td>
<td>Gases which may be inadvertently present in a refrigerating system.</td>
</tr>
<tr>
<td>Occupational Exposure Limits</td>
<td>The airborne concentration of a substance to which it is believed that nearly all workers may be repeatedly exposed on a daily basis without adverse health effects. Attention is drawn to Regulation 2 of the Control of Substances Hazardous to Health Regulations 2002 and the Health and Safety Executive Environmental Hygiene Guidance Note EH40/4.</td>
</tr>
<tr>
<td>Occupied space</td>
<td>Space in a building which is bounded by walls, floors and ceilings and which is occupied by persons for a significant period. Where the spaces around the apparent occupied space are, by construction or design, not air tight with respect to the occupied space, these may be considered part of the occupied space eg false ceiling voids, ducts, movable partitions and doors with transfer grilles. Machinery rooms as defined in BS EN 378-2:2016 are not classed as occupied spaces.</td>
</tr>
</tbody>
</table>
### Piping
All piping covered in the scope of BS EN14276-2:2007 such as pipes or tubes (including hoses, bellows, fittings or flexible pipes) for interconnecting the various components of a refrigerating system.

### Practical Limit
Concentration used for simplified calculation to determine the maximum acceptable amount of refrigerant in an occupied space.

### Pressure
The following define the various pressures referred to in IOR Codes:

- **Design pressure** of a component is the pressure used to determine the required material thickness and construction to maintain its pressure integrity.

- **Maximum allowable pressure (PS)** is the maximum pressure which the system or component is designed for, as specified by the manufacturer. Refer to the Pressure Equipment Directive 2014/68/EU. This is the pressure that shall not be exceeded when the system is in operation or at rest except within the operating range of any necessary pressure relief device. The pressure at which a pressure relief device begins to operate shall not exceed the maximum allowable pressure. It may be differently specified for the high and low pressure sides of the refrigerating system.

- **Strength pressure** is the pressure that is applied to test the strength of a refrigerating system or any part of it.

- **Tightness test pressure** is the pressure that is applied to test a system or any part of it for pressure tightness.

- **Gauge pressure** is the difference between the absolute pressure and atmospheric pressure and is indicated by a pressure gauge. Atmospheric pressure is generally assumed to be 1.013 bar absolute (14.7 lbf/in²) at sea level.

- **High pressure side** (HP Side) is the part of the refrigerating system operating at approximately the condenser or gas cooler pressure.

- **Intermediate pressure section** is the section of a refrigerating system subject to intermediate pressure of a multi-stage system.

- **Low pressure side** (LP Side) is the part of the refrigerating system operating at approximately the evaporating pressure.

### Pressure Integrity
The capability to prevent an unintentional release of refrigerant from the system.

### Pressure Limiter
Safety switching device for limiting the pressure which automatically resets.

### Pressure Relief Device
Pressure relief valve or bursting disc designed to relieve excessive pressure automatically.

### Pressure Relief Valve
Pressure actuated valve held shut by a spring or other means and designed to relieve excessive pressure automatically by starting to open at a set pressure and re-closing after the pressure has fallen below the set pressure.

### Refrigerant
A substance used to produce refrigeration by its vapourisation. For the purposes of this Code the term Refrigerant refers to fluids classified according to safety group in ISO 817:2014.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerating System</td>
<td>A combination of interconnected refrigerant-containing parts constituting one closed circuit in which the refrigerant is circulated for the purpose of extracting and delivering heat (i.e., heating and cooling).</td>
</tr>
<tr>
<td>Sealed System</td>
<td>Refrigerating system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair and disposal and which have a tested leakage rate of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure. Hermetically sealed systems in BS EN 16084:2011 are equivalent to sealed systems.</td>
</tr>
<tr>
<td>Separate Refrigeration Machinery Room</td>
<td>Machinery room intended to contain only components of the refrigerating system, accessible only to competent personnel for the purposes of inspection, maintenance and repair.</td>
</tr>
<tr>
<td>Short Term Exposure Limit</td>
<td>The STEL is a concentration measured as a time-weighted average over 15 minutes, which, for various substances, is listed in EH40. For substances assigned both an 8-hour LTEL and a 15-minute STEL the total duration of concentrations above the 8-hour time weighted average should be limited to 1 hour in a 24-hour period and should not exceed the value of the STEL (EH40: para 23 refers).</td>
</tr>
<tr>
<td>Transcritical</td>
<td>Refrigerating system where the compressor discharges refrigerant at a pressure above the critical point.</td>
</tr>
<tr>
<td>Type Approved Safety Switching Device for limiting the pressure</td>
<td>A pressure-activated device designed to stop the operation of the pressure generator e.g., compressor.</td>
</tr>
<tr>
<td>Unit Systems</td>
<td>Self-contained system that has been assembled, filled ready for use and tested prior to its installation and is installed without the need for connecting any refrigerant-containing parts.</td>
</tr>
<tr>
<td>Welded Joint</td>
<td>A joint obtained by the joining of metal parts in the plastic or molten state.</td>
</tr>
</tbody>
</table>
Appendix B – Maximum Allowable Pressure and Strength Test Procedure

Reference is made in Section 3 of this Code to the maximum allowable pressure (PS), which may be separately specified for the high-pressure side and the low-pressure side of the system. The PS of the system or parts of the system should be recorded in the system register.

The PS of the system or parts of the system may differ from the design pressure stamped on individual components. The design pressure of any component shall not be lower than the PS of the system, but could be higher.

For systems designed and installed in accordance with this Code minimum values for the design pressure, strength pressure and tightness test pressure for the components of the system are specified in Table 2 of section 2. Where the PS of a system or part of a system is higher than the minimum pressure given in table 2 then corresponding higher design, strength and tightness test pressures shall be applied.

Appropriate safety precautions shall be observed for all pressure testing. Reference shall be made to Appendix C of this Code and to the Health & Safety Executive Guidance Note GS4 ‘Safety in Pressure Testing’.

A strength test followed by a tightness test shall be carried out on all repaired piping and components of a refrigerating system. Replacement components should be strength tested prior to fitting to the system.

TABLE B1 - Specified Design temperatures from BS EN 378-2:2016

<table>
<thead>
<tr>
<th>Ambient Dry Bulb Conditions</th>
<th>≤32°C</th>
<th>≤38°C</th>
<th>≤43°C</th>
<th>≤55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure side with air cooled condenser</td>
<td>55°C</td>
<td>59°C</td>
<td>63°C</td>
<td>67°C</td>
</tr>
<tr>
<td>High pressure side with water cooled condenser or water heat pump</td>
<td>Maximum leaving water temperature + 8K but not less than the design temperature at low pressure side.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High pressure side with evaporative condenser</td>
<td>43°C</td>
<td>43°C</td>
<td>43°C</td>
<td>55°C</td>
</tr>
<tr>
<td>Low pressure side with heat exchanger exposed to the outdoor ambient temperature</td>
<td>32°C</td>
<td>38°C</td>
<td>43°C</td>
<td>55°C</td>
</tr>
<tr>
<td>Low pressure side with heat exchanger exposed to the indoor ambient temperature</td>
<td>27°C</td>
<td>33°C</td>
<td>38°C</td>
<td>38°C</td>
</tr>
</tbody>
</table>

Note 1: For the high pressure side the specified temperatures are considered the maximum which will occur during operation. This temperature is higher than the temperature during compressor shut down (standstill). For the low pressure side and/or intermediate pressure side it is sufficient to base the calculation of pressure on the expected temperature during compressor standstill period. These temperatures are minimum temperatures and thus determine that the system will not be designed for maximum allowable pressure lower than the saturated refrigerant pressure corresponding to these minimum temperatures.

Note 2: The use of specified temperatures does not always result in saturated ammonia pressure within the system eg a limited charge system.
Note 3: The system may be subdivided into parts (e.g. low and high pressure sides) for which there might be different allowable pressures.

Note 4: The pressure at which the system (or part system) normally operates should be lower than the allowable pressure.

Note 5: Excessive stresses can result from gas pulsations.

Table B2 — Relationship between the various pressures and the maximum allowable pressure (PS)

<table>
<thead>
<tr>
<th>Description</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design pressure</td>
<td>≥PS</td>
</tr>
<tr>
<td>Strength test pressure</td>
<td>refer to Section 5.2 of this Code</td>
</tr>
<tr>
<td>Tightness test pressure for assemblies</td>
<td>≤1.0 × PS</td>
</tr>
<tr>
<td>Setting of safety switching device for limiting the pressure for systems with relief device</td>
<td>≤0.9 × PS</td>
</tr>
<tr>
<td>Setting of safety switching device for limiting the pressure for systems without relief device</td>
<td>≤1.0 × PS</td>
</tr>
<tr>
<td>Setting of pressure relief device</td>
<td>1.0 × PS</td>
</tr>
<tr>
<td>Pressure relief valve achieves the required flow at 1.1 PS</td>
<td>≤1.1 × PS</td>
</tr>
</tbody>
</table>
Appendix C – Pneumatic Strength Pressure Test Procedure

Pneumatic strength testing of systems including pressure equipment shall only be permitted where the equipment carries a plate or other certification confirming an earlier strength test at an equal or higher pressure as defined in Appendix B of this Code. Pneumatic strength test pressure shall not be applied until a risk assessment has been completed by a competent person. A full visual inspection of the equipment shall precede a pneumatic test and if necessary the visual inspection should be supplemented by radiographic or other non-destructive testing. Where no record of a recent strength test exists, a hydraulic test for strength to the pressure as defined in Appendix B shall be carried out. Where the condition of the equipment indicates deterioration then the hydraulic test shall be mandatory. Further information on pneumatic and hydraulic testing including the safety precautions necessary before and during pressure testing is contained in the HSE Guidance Note GS4 “Safety Requirements for Pressure Testing”.

Where a pneumatic test is possible the test shall be carried out using oxygen free nitrogen (OFN) or other suitable inert gas.

The means to build up pressure for test purposes shall have a pressure limiting relief device, reducing valve (with gauge) or other device for preventing pressure from exceeding the safe limit.

Prior to the tests steps shall be taken to ensure the safety of people and to minimise risk to property.

All ammonia shall be recovered from the equipment to be tested and the equipment then isolated effectively from the remainder of the system. The use of blanking plates between flanges or sections of line open to atmosphere beyond stop valves are typical ways to prevent leakage of the test medium into the remainder of the system.

Pressure relief valves or bursting discs which will be set at or selected for the maximum allowable pressure PS and would therefore operate shall be removed and all connections adequately sealed prior to test. Instruments and controls which could be damaged by over pressure shall be removed. It may be appropriate to use the relief valve connection to accommodate a test pressure gauge and it may be convenient to carry out replacement of relief valves following a pressure test.

Means shall be provided to ensure that the intended pressure is not exceeded. If the source of pressure is at a higher pressure than the test pressure a reducing valve should be used together with a relief valve. The equipment to be tested shall be fitted with a pressure gauge connected to the equipment at a point other than the test pressure connection (in addition to the gauge at the reducing valve).

Both the test pressure connection and the gauge shall be located so that testing can proceed without exposing the operator or other personnel to danger.

A calibration record indicating the accuracy of the test gauge should be available.

Pressure shall be raised gradually to avoid shock. An initial examination for major leaks, for example at connections, may be made at low pressure (typically 10% of the final pressure) but during further pressurisation and for the first few minutes at test pressure no-one shall approach the equipment.

Once the equipment strength pressure integrity has been confirmed the pressure shall be reduced to the tightness test pressure and a tightness test shall be conducted.
Following a successful test the pressure shall be reduced to atmospheric and pressure relief valves and controls replaced. Connections to these should be leak tested when refrigerant is re-admitted during recommissioning. The test conditions and date, together with any comments, shall be entered in the system register.

Where a vessel which has previously been hydraulically tested to 1.43 x PS or greater is to be pneumatically strength tested as part of a system, it is recommended that the system test pressure should not exceed PS x 1.1.

Where it is practical to isolate previously tested vessels checks shall be made to ensure that the test pressures applied were not less than the system maximum allowable pressure.
Appendix D – Marking and Name Plate Data

D.1 Refrigerating Systems Installed on Site

Safety instructions relating to ammonia shall be prominently displayed both in and adjacent to machinery rooms.

Where applicable the equipment shall be CE marked and labelled in accordance with the Pressure Equipment Directive (Essential Safety Requirement 3.3).

In addition to the PED requirements the following information shall be provided on permanently attached component nameplates. Where nameplates are not readily visible a second plate marked “Duplicate” shall be provided and fixed nearby in a clearly visible position.

Piping shall be marked by colour coding in accordance with National Standards.

<table>
<thead>
<tr>
<th>Information</th>
<th>Unit Systems</th>
<th>Other Systems</th>
<th>Compressors</th>
<th>Refrigeration Pumps</th>
<th>Pressure Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer’s name</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer’s model/type</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer’s serial no.</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of manufacture</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installer’s name and address</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of installation</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum allowable pressure(s)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Test pressure(s) applied</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Internal gross volume</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design temperature</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum temperature</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Code and Date</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name and Stamp of Insp. Auth’y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerant number</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Refrigerant GWP, whether it is an HFC</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerant charge as CO₂ equivalent</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum rotational speed (rpm)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Direction of rotation</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Type of lubricant</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow direction</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric supply (V-A-Hz-phase)</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
<tr>
<td>Nominal power absorbed (kW)</td>
<td>☑</td>
<td></td>
<td>☑</td>
<td></td>
<td>☑</td>
</tr>
</tbody>
</table>

Notes:

a For compressors the information must be given for each section of the machine. High pressure side and low pressure side for a single stage machine; high, low and intermediate pressure for a two-stage machine.

b For pressure vessels where the allowable pressure exceeds 0.5 bar gauge and where the product of the internal gross volume in litres and the allowable pressure in bar gauge exceeds 250. Where pressure vessels are multi-circuited, e.g. for heat exchangers, allowable and test pressures must be shown for each circuit.

Suitability for use with specific secondary fluids shall be indicated. Plate heat exchangers shall be marked as if they were pressure vessels

c Liquid Receivers

d Electric motor compressors only
Other components that shall be clearly marked are:

a) for gas, air, water, electricity services
   • main shut-off valves
   • main controls

b) for refrigerating systems
   • remote control devices
   • pressure limiting devices.
Appendix E - Handling, Transport and Storage of Refrigerant Cylinders

European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances (the CLP Regulation or CLP) provides a globally harmonised system on labelling of chemicals.

E.1 Handling of Cylinders

Guidance on handling of ammonia cylinders is as follows:

- Do not remove or obscure official labelling on a cylinder
- Always refit the valve cap when the cylinder is not in use
- Use and store cylinders in the correct orientation.
- Check the condition of the thread and ensure it is clean and not damaged
- Store and use cylinders in dry, well-ventilated areas
- Do not expose cylinders to direct sources of heat such as sunlight, steam, gas flames or electric radiators
- Do not repair or modify cylinders or cylinder valves
- Always use a cylinder trolley for moving cylinders even for a short distance – never roll cylinders along the ground
- Take precautions to avoid oil, water and foreign matter entering the cylinder
- If it is necessary to warm the cylinder, use only thermostatically controlled heater jackets, warm water or air, not naked flames or radiant heaters. The temperature of the water or air must not exceed 40°C
- Always weigh the cylinder to check if it is empty. Pressure is not an accurate indication of the amount of refrigerant that remains in the cylinder
- Use only dedicated recovery cylinders for the recovery of refrigerants

E.2 Transportation of Cylinders

The regulations covering the transportation of cylinders is “The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulation 2009” and these implement ADR 2015.

- Suitable protective valve caps and covers should be fitted before transportation.
- Cylinders should be suitable stowed to prevent them moving or falling. This is normally in the vertical position unless instructions say otherwise.
- Disconnect regulators and hoses from cylinders.
- Do not let cylinders project beyond the sides or end of the vehicle.
- Ensure cylinders are clearly marked to show their contents
- Ensure that the vehicle is suitable for purpose and marked to show that it is carrying dangerous goods.
- The driver should be suitably trained and has documentation about the nature of the refrigerant being carried
E.3 Storage of cylinders

The British Compressed Gases Association Guidance Note on the Storage of Gas Cylinders in the Workplace (GN 2 - Rev 5 – 2012. ISSN 0260-4809) defines the principles of safe practice for the storage of gases in cylinders.

Cylinders should be preferably stored outside and never stored in residential premises. Cylinders may be stored in commercial and industrial premises according to the following guidelines for storage:

- Cylinders are stored in specific dedicated areas.
- Access to the storage areas is restricted to authorised persons only.
- Cylinders should be readily accessible, and stored upright.
Appendix F – Commissioning of New Installations

F.1 General

A typical procedure to be followed during commissioning is given below for guidance but it is emphasised that the procedure may need to be varied to suit the machinery, location and duty of any individual refrigerating system. Special attention should be given to manufacturer’s instructions. Compliance with PSSR 2000 and DSEAR 2002 is required prior to setting the system to work.

F.2 Initial Status and Safety Provisions

Individual commissioning procedures may commence before piping, electrical equipment and thermal insulation have been installed but final commissioning procedure cannot be completed until the system in all its parts is complete.

During commissioning in confined spaces or basements or other high-risk areas consideration should be given to having self-contained breathing apparatus available.

F.2.1 Off-Site Preparation

The commissioning engineer shall have ready access to those responsible for the installation of the refrigerating system and associated equipment.

Relevant drawings, including a refrigeration circuit or flow diagram and an electrical circuit diagram, shall be available on site for the commissioning engineer together with data relating to the designed performance and the normal working and limiting design conditions.

Documentation relating to pressure vessels shall be available. Confirmation that selected welds on piping are in accordance with the appropriate welding Standards shall be available, including the results of non-destructive testing examination.

F.2.2 Site Preparation

The machinery room, any other spaces containing parts of the system and all escape routes and walkways shall have been cleared of all portable equipment and other obstructions that could hinder access or escape in an emergency. Emergency lighting and ventilation fans (including emergency ventilation fans) shall be commissioned and ready for operation.

First aid and safety equipment shall be available as appropriate to the mass of ammonia charge in any one system and to plant location. For further information see Appendix G.

Unauthorised persons should be excluded from the area where commissioning is taking place.

A visual inspection using a written checklist shall be carried out on all piping joints, electrical wiring and brackets for piping and cables to ensure that prior to commencement of commissioning no incorrect connections, loose brackets, contact between cables and potentially hot pipes, missing covers or guards have been overlooked.

Checks should be made to ensure that all pressure gauges have sufficient range for that part of the system to which they are connected and are appropriate for ammonia.

A notice should be mechanically attached to the charging valve to indicate that the system is to be
charged with ammonia.

The type of oil recommended for use in the particular system should be confirmed and used.

Oil levels in compressors should be checked. It should be verified that the correct oil charges have been added to oil reservoirs, oil rectifiers, remote reading sight-glasses, oil separators, pedestal bearing sumps, mechanical lubricators and flooded evaporator systems.

All water circuit components and evaporative condensers should be flushed out and cleaned in accordance with BSRIA AG1/2001 and ACOP L8.

### F.3 Electrical Equipment

The commissioning engineer should

a. verify that a visual inspection of electrical wiring, containment and control panels, both internally and externally, has been carried out,

b. verify that all specified equipment has been correctly installed, including the fitting of fuses or circuit breakers of the correct rating as indicated in the specification.

c. obtain appropriate certificates verifying that the electrical equipment has been subjected to a test voltage according to BS EN 60204-1:2006

d. ensure that the electrical installation has been tested in accordance with BS7671

e. receive appropriate certificates verifying that the control panels have been flash tested

f. verify that an insulation test of all cables and equipment to ensure that no faults exist has been carried out

g. receive confirmation that an earth loop impedance test has been carried out

All main drive motor, pump and auxiliary equipment fuses shall then be removed allowing only the control circuit to be energised. Where the main drive is other than by electric motor, appropriate alternative procedures should be adopted to ensure that it cannot be started.

With the control circuit operational all circuits shall be tested individually to ensure they are in the correct state in all situations. All safety switches, including emergency stop switches, shall be operated to ensure they make or break the necessary circuits.

Where appropriate and with main drive fuses removed, the coupling or V belts between the prime mover and the compressor should be disconnected and the machinery rotated by hand to ensure that it revolves freely.

Fuses shall be fitted individually to auxiliary equipment drives and these tested for direction and operation. Check the motor overload settings and adjust accordingly.

Care should be taken not to prolong these checks particularly with pumps that are lubricated by the working fluid. Correct rotation of hermetic refrigerant pumps cannot normally be checked until the system is sufficiently charged.

With the drive belts or coupling removed the main drive motor fuses shall be fitted and the motor started and checked for operation and correct direction of rotation. In certain cases it may be necessary to link out various electrical interlocks in order to test run the motor.

With multi stage starters e.g. star delta and part wind starters, their motors should be run up to full speed to confirm that each step is operating in the correct sequence and with the correct time intervals between the steps.
If the direction of rotation is correct the motor supply shall be securely isolated then the drive reconnected, correctly aligned and the appropriate guards fitted.

When the above circuit tests are satisfactorily completed all safety switches shall be set to the values required by the design specification.

The System Register shall contain a record of these tests, which shall be completed before the system is charged.

**F.4 Evacuation and Charging**

**F.4.1 Evacuation and Dehydration Procedure**

On the successful completion of the strength and tightness tests to the requirements of this Code, the inert gases from this procedure should be released from the system through a suitable vent to a safe place. Oil shall then be added if appropriate and preparations made to evacuate and dehydrate the system.

Under no circumstances shall the system compressor be used as a vacuum pump for this operation. A vacuum pump of the gas ballast type appropriate to the volume of the system should be selected. It should be checked for effective operation, and then connected to both the high and low-pressure sides of the system. In order to achieve the best efficiency from the vacuum pump, the connecting pipes should be of the largest diameter possible and kept to a minimum length. A suitable vacuum gauge should be connected to the system at the furthest connection point from the vacuum pump. A standard pressure gauge is not sufficiently accurate.

Precautions shall be taken to ensure that there are no isolated sections of the system and any vulnerable components should be protected during this operation.

The object of the evacuation procedure is to remove non-condensable gases and moisture from the system. Failure to achieve the desired vacuum may indicate that the system is not gas-tight or contains moisture.

Evacuation must achieve a pressure of 10 mm Hg Abs (10 Torr, 10,000 microns, 1350Pa). To ensure that the system is free of leaks the pressure must be maintained without significant rise for at least one hour with the vacuum pump isolated. If triple evacuation is carried out the vacuum shall not be broken with refrigerant at any of intermediate stages. Oxygen free nitrogen (OFN) should be introduced to the system while the vacuum pump is isolated.

All drier cores and filter elements should be fitted before the final evacuation cycle.

The compressor may be left isolated during the above procedure. It shall then be opened to the system during the final stage of the evacuation procedure in order to withdraw any gas holding charge that may be present.

**F.4.2 Charging Procedure**

When the system has been successfully evacuated, the commissioning engineer shall fit calibrated pressure gauges and thermometers to the system for use during the charging and commissioning procedure.
After final evacuation, the vacuum should be broken with ammonia vapour until the system pressure has reached a level which avoids any adverse effects of low temperature such as water freezing or brittle fracture.

Only one ammonia container should be connected to the system at a time. The connecting point will depend on the type of system and whether charging is by gas or liquid. Care shall be taken to ensure that liquid ammonia does not enter the compressor.

Charging equipment shall be suitable for use with ammonia and shall be rated for an allowable pressure of at least 56 bar g. Fixed charging lines shall comply with Section 4.3 of this Code. Where the refrigerant container is fitted with separate outlets for vapour or liquid off-take, the charging line shall be fitted to the appropriate connection. If there is only one outlet on the container, liquid or vapour can be obtained by orientation of the container.

The container for charging the system should be securely supported and located in a position where it will not cause a hazard to other personnel involved on the site and a notice posted to indicate that it is being used for charging.

When changing containers during the charging procedure, care must be taken not to trap liquid ammonia between isolating valves.

When sufficient ammonia has been charged into the system and there is suitable heat load to maintain operation, the compressor should be started in order to reduce the low side pressure and enable the charging process to be completed.

If the container pressure drops too low for effective charging the pressure may be increased by gently applying heat at less than 40°C. On no account shall a flame be used, nor shall the container be heated to over 40°C.

During this procedure the operation of the compressor shall be monitored and details recorded of all its mechanical and electrical operating parameters. It shall be shut off if any signs of abnormal operation are seen or heard. Extra care shall be taken until there is an adequate charge of ammonia in the system as the compressor could be operating outside its normal range of temperatures and pressures. The system shall not be left unattended during the charging process.

The quantity of ammonia charged shall take account of all operating conditions that can exist over the ambient temperature design range. When completed the total weight of ammonia charged into the system shall be recorded in the System Register.

Ammonia containers should be disconnected as soon as charging is completed. When the system has been fully charged the protection devices shall be tested as in F.5 below.

**F.5 Testing of Protection Devices**

It is recommended that these tests are carried out with the compressor at minimum capacity when it is fitted with capacity control. If any switch fails to operate when tested, the fault(s) shall be traced and rectified before the refrigerating system is put back into operation. After fault correction, the test shall be repeated.

**F.5.1 High Pressure Switch**

The high pressure switches shall be tested first. The compressor discharge pressure shall be
increased slowly until the commissioning engineer can confirm that the cut-out operates at the required setting. Two persons should be employed in this test; one of whom should continuously monitor the pressure gauges. If the pressure exceeds the switch setting the compressor shall be stopped immediately.

F.5.2 Oil Differential Pressure Switch

Dependent on the type of compressor, the oil pressure switches may have an associated delay, giving necessary time for adequate oil pressure to be obtained on start up. This should be taken into consideration during test procedures.

The delay timer should be tested by either:

a) Simulating a start with the electrical controls while the compressor motor is electrically isolated

b) Isolating the oil pressure switch from the lubrication circuit, if suitably valved.

c) Using a built-in test facility, if fitted.

The oil switch pressure setting should be tested by a suitable method.

If the switch fails to operate, it shall be replaced.

F.5.3 Low Pressure Switch

The low pressure switches if fitted, shall be tested by reducing suction pressure by gradually closing the compressor suction shut-off valve, taking care to minimise oil foaming in the compressor. It shall be confirmed that the switch operates at the required pressure. If the suction pressure reaches the minimum recommended by the system designer and the switch has not operated either the compressor shall be stopped or suction pressure increased by opening the partially closed valve immediately. The test should then be repeated and if the same result is obtained, the low pressure switch should be adjusted or replaced.

F.5.4 High Temperature Switches

Discharge temperature or oil temperature switches shall not be tested by increasing the temperature of the relevant part of the system. Where necessary they shall be tested, for example by immersion of the sensor in a heated bath of suitable liquid.

F.5.5 Compressor Motor Protection

Compressor motor protection against overheating is often provided by the manufacturers of hermetic and semi-hermetic compressors. Site testing is not generally practical, although some manufacturers may give instructions. The main methods of protection are either:

a) A sensor or sensors embedded in the motor windings which may operate through an external control module

b) By a sensor attached to the motor end of the compressor body. This sensor may be either temperature or current sensitive or a combination of both.
In addition to the above options, some manufacturers also recommend that overloads are fitted to the compressor starter. (Section 3.3 of this Code refers).

Motors of open drive compressors use current sensitive relays in the motor starter and may in addition be fitted with embedded sensors as item a) above.

**F.5.6 Other Protection Devices**

All other pressure, limit and alarm switches such as liquid level controls and low temperature cut-outs shall be tested for operation and adjusted to the requirements of the system designer. The operation of all oil heaters and any ammonia detectors shall be verified.

**F.5.7 Further Monitoring**

When the above tests have been completed satisfactorily the commissioning may proceed, including the adjustment of regulating and control valves and all level controls to achieve correct function.

Throughout the whole commissioning procedure there shall be frequent monitoring of pressures and temperatures in the system and vigilance for ammonia leakage. At any abnormal indication the compressor shall be stopped immediately.

All solenoid valves shall be inspected to ensure that when closed they are not allowing migration of ammonia or oil to parts of the system at a lower pressure.

**F.5.8 Demonstration Run**

Demonstration run as defined here does not necessarily include a full performance demonstration, which would need to be specified separately if required.

The system shall be run under the available heat load to demonstrate correct function. During the run pressures and temperatures shall be recorded. Liquid levels in sight glasses should be identified (for the heat load available) and recorded.

The commissioning engineer should endeavour to involve during the demonstration test run such persons as will be responsible for the day to day running of the system. The installation should be handed over after safety and protective/automatic control functions have been demonstrated and there has been a previously agreed period of continuous and fault free running.

The operating staff should continue to log pressures, temperatures and levels and to inspect the system for leaks, oil consumption and other abnormalities at frequent intervals over the first weeks of operation. This should not be confined to the machinery room but include the whole refrigerating system.

The supplier’s instructions on oil and filter changes during commissioning and the first weeks of operation shall be observed.

**F.5.9 Hand Over of Information**

The installing contractor shall hand over to the user information relevant to the design, maintenance, working procedure and safety aspects of the system. This can include:

1. A manual containing operating instructions for individual equipment in the system
b. A refrigerating system circuit or flow diagram with Pressure Temperature relationship data
c. A chemical safety data sheet for the ammonia and other substances in use (this is a statutory requirement)
d. The electrical wiring diagram
e. A starting and stopping procedure, including emergency stop instructions
f. Stopping and restarting procedure for prolonged shutdown
g. Details of all motor power ratings, equipment supplier, serial numbers and test certificates for pressure vessels, piping and other equipment
h. Details of safety procedures to be used in the event of an emergency
i. Methods of ammonia leak detection using portable equipment or fixed equipment or monitoring equipment as fitted
j. Recommended list of oils, lubricants and spares for critical equipment to be used and recommended frequency of change
k. Other data as in Sections 3, 6 and 8 of this Code.

In addition the commissioning engineer shall hand over a full set of Commissioning Records and other data, which has been compiled during the commissioning. This shall include:

a. A complete log taken during the test period to ensure that a standard of operation is available at all times for the operating staff. This might not include a full load run and might not necessarily be representative.
b. A sheet signed by the commissioning engineer and containing the settings of all safety devices.
c. Relevant additional comments
d. If any thermal images of electrical connections or insulation, or any video images are taken these shall also be made available.

The user of the system has a duty to arrange instruction for staff so that, so far as is reasonably practicable, the system can be operated and maintained in safety.

F.5.10 Electronic Monitoring Equipment

Where electronic controls are installed to monitor the operation of refrigeration systems the following shall apply:

a. Sensors for high pressure, oil differential and low pressure switches. The switching shall be tested as stated in F.5.1, F.5.2 and F.5.3 respectively.
b. The operation of high temperature cutouts shall be tested by temporarily lowering the setpoint to a value which causes a trip during normal operation. The cutout shall not be tested by increasing the temperature of the relevant parts of the system.
c. Instruments indicating loss of ammonia, which sense either liquid level in the receiver or vapour concentration in the atmosphere should be tested to the manufacturer’s instructions and suitably calibrated.
Appendix G – Machinery Rooms and Auxiliary Safety Equipment

G.1 General

Inspection at commissioning and as part of maintenance shall ensure that the following requirements are met prior to charging with ammonia and continue to be met during the operation of the system.

The Confined Spaces Regulations (1997) may apply. Refer to the HSE Guidance Note on Safe Work in Confined Spaces (ACOP L101).

G.2 Access, Exit and Containment

Refrigeration machinery rooms shall be sized so that all parts are easily accessible with adequate space for proper service, maintenance and operation. There shall be clear headroom of not less than 2.1 m below equipment situated over gangways. Rooms shall have doors opening outwards, self-closing, well-fitting and with a fire rating appropriate to the machinery room construction if opening to other parts of the building. The doors shall be adequate in number to allow persons to escape in an emergency. Gangways and exits shall be clear of any obstruction and should be plainly marked. Provision shall be made to facilitate immediate exit from the machinery room in the event of an emergency. At least one of the emergency exits shall open directly to the open air, or it shall lead to an emergency exit passageway. The doors in the emergency exits shall be such that they can be opened manually from the inside.

Machinery rooms shall be ventilated to the outside of the building by means of grilles, windows or door openings and/or mechanical ventilation as in G.7 below. Exterior openings shall be positioned so as not to cause nuisance or danger.

There shall be no openings that could permit the passage of escaping ammonia to other parts of the building.

Fire extinguishers shall be installed in accordance with local fire authority requirements and notices describing their correct usage shall be posted.

Warning notices should be displayed at the entrances to the machinery room stating that smoking, naked lights and flames are prohibited.

Boilers and other open flame devices or combustion equipment shall not share the space. Air intakes for any equipment shall not be taken from within the machinery room.

Explosion relief provisions shall be made if it is possible for the refrigerant in the machinery room to reach a concentration above the LFL.

G.3 Instruction

Operating and Maintenance personnel shall be instructed in the operation of the system and possible hazards. Refer to section F.5.10 of this Code. Instructions shall be repeated when new personnel or subcontractors are appointed.

Concisely worded Operational Instructions for normal starting and stopping and for the emergency stopping of the equipment shall be prominently displayed in the machinery room.
Warning and first aid notices appropriate to the equipment and to ammonia shall be displayed in the machinery room and its points of entry. Any first aid personnel shall be made fully aware of the potential health hazards which may result from exposure to or contact with system fluids. Section 2.2 of this Code refers.

A manufacturer’s Instruction Manual shall be readily available and should include at least the following:

a) Full details of the system
b) Ammonia charge quantity
c) Description of the machinery
d) Detailed starting, stopping and running instructions
e) Information on possible faults, repair and maintenance schedules
f) A refrigeration flow diagram and an electrical circuit diagram
g) Pressure-Temperature relationship and Chemical Safety Data Sheets for ammonia.

G.4 Protective Equipment

Appropriate personal protective equipment should be worn by all personnel working on refrigerating systems when opening the system for service, maintenance, charging or purging.

In certain circumstances it may be necessary to provide self-contained breathing apparatus, full protective clothing and a lifeline external to the area of risk for use by trained personnel where rescue work or emergency isolation of equipment may have to be undertaken. Basement plant rooms are a particular hazard and reference should be made to Section 2.2 of this Code.

Appropriate fire fighting equipment shall be provided.

Appropriate first aid equipment shall be provided. Concise first aid instructions shall be clearly displayed in the machinery rooms and at their points of entry.

Regular first aid personnel shall be made fully aware of the special hazards associated with ammonia.

Irrigation facilities and eye wash bottles containing an eye wash solution or distilled water should be available. The solution should be changed at least every six months.

The location of all protective, first aid and rescue equipment shall be clearly indicated. Such equipment should be examined monthly and the inspection dates noted in the System Register, together with any action taken.

G.5 Electrical

Lighting shall be adequate for the tasks to be performed and shall allow safe movement of personnel. An emergency lighting system shall be provided to allow evacuation of personnel and any necessary urgent operation of controls. Alternatively portable lighting shall be provided.

Lighting intended to remain in operation following an accidental release of ammonia shall be suitably protected for use in a hazardous Zone 2 area in accordance with BS EN 60079-0:2012 (+A11:2013).

Independent or standby supplies of electricity (for example batteries) for emergency and warning systems should be tested at monthly intervals.
An emergency stop button (or buttons) shall be provided in the machinery room and at an appropriate location outside the room. Emergency stop buttons shall stop all refrigerating machinery.

Ammonia/air mixtures can be explosive, but only at the unusually high concentration of 16% to 27% by volume if ignited by a high temperature source; a low concentration of 0.01% is readily detected by smell and by suitable detectors. Accordingly the following precautions a) to c) shall be taken:

a) In machinery rooms of refrigerating systems containing ammonia, isolation of all non-flameproof electrical circuits shall be effected by circuit breaker(s) installed in a safe place. The circuit breakers shall be controlled both:

i. by an automatic ammonia detection systems set to operate at a concentration of not more than 3%, and preferably less than 1% of ammonia in air by volume. Detector heads should be installed over non-static items of equipment from which a leakage might occur.

ii. by break glass point(s) immediately outside the machinery room exit doors on a similar basis to the provision of fire alarm buttons for hazardous areas.

b) Automatic ammonia detection system shall have a lower alarm level set at not more than 0.05% of ammonia in air by volume, at which concentration the detection system should activate visual and audible alarms, locally and in a supervised location, and switch on equipment for ventilation in accordance with F.6 below and flameproof emergency lighting (if installed). These actions should be continued at the higher alarm level referred to in (a) i above, and also be initiated by the break glass point(s) referred to in (a)ii above.

c) Where fan motors, emergency lighting or ammonia detectors are required to operate after a leakage has been detected they shall comply with the requirements of the hazardous area in which they are situated. The construction and materials of fans shall not be conducive to fire or sparking.

The installation of one or more clearly labelled additional emergency push buttons remote from the area or enclosed space but duplicating the action of those in (a)ii above should be considered. Regular tests of the effectiveness of detection and isolation systems should be made, at intervals not exceeding 3 months.

G.6 Refrigerant Detection

Refrigerant vapour detectors shall be provided in machinery rooms to activate an alarm and to automatically switch on ventilation fans if the concentration of refrigerant in the room could exceed 20% of the lower flammable limit. The device shall initiate an alarm which shall be in the form of an audible signal and a flashing light in the machinery room and also externally so that emergency action may be initiated.

Sampling points should be installed at strategic locations within machinery rooms so that damage is avoided during normal use of the machinery room. Points should be located so that they provide rapid signals in the event of a leak, and that the effect of air movement does not inhibit their effectiveness. Refrigerant leak detectors shall be calibrated for the specific refrigerant they are intended to detect.

A detector sampling point can normally cover an area of approximately 36m² provided it is mounted at floor level. The gas detectors response time shall be 30 seconds or less.
G.7 Ventilation

Ventilation in accordance with BS EN378-3:2016 shall be installed. Inlet and extract grilles shall be free from obstruction and shall be suitably guarded. Discharge to the outside of the building shall be free from obstruction and shall be located so as not to cause danger. Adequate provision shall be made for distributing replacement fresh air throughout the room.

Ventilation shall provide a minimum of four air changes per hour when the machinery room is occupied.

A formal risk assessment conducted in accordance with the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 may indicate that the requirements of the regulations can be achieved by the provision of appropriate continuous background ventilation. The risk assessment should be specific to the machinery room in question and recorded in writing. It should be reappraised if any significant modification is made to the plant or the room. The ventilation shall meet the requirement of BS EN 60079-10-1:2015 Classification of Areas as required by DSEAR. If ventilation is used as the primary method of ensuring compliance then it shall be operated continuously and shall sound an alarm and isolate the electrical supply to the machinery room in the event of ventilation failure. The appropriate background ventilation rate shall be determined by a risk assessment in accordance with DSEAR.

Mechanical ventilation shall be activated by an independent emergency control outside and near the machinery room door (with another at ground level if the machinery room is not at ground level).

Where the system is not installed in a machinery room but is in a ventilated enclosure located in an occupied space then the requirements of BS EN378-2:2016 paragraph 6.2.15 shall apply. The detector and ventilation function shall be checked at regular intervals according to the manufacturers' instructions.

G.8 Guards

Adequate guards shall be fitted to prevent access to and injury from all rotating machinery, dangerously hot or cold surfaces and live electrical terminals. Refer to PD 5304:2014 Guidance on Safe Use of Machinery.

G.9 Ammonia Storage

Ammonia shall be stored in the manufacturer’s containers, securely supported. Storage areas should be adequately ventilated and free of flammable materials.

Ammonia containers shall not be stored where temperatures can exceed 45°C and should not be stored in a machinery room, basement or area with poor ventilation.
Appendix H – Typical Schedule for Inspection and Maintenance

The tables below show example formats for inspection and maintenance schedules. It should be emphasised that the user of the refrigeration system should draw up a scheme that is appropriate to the range of equipment installed.

The user should identify the relevant grade of staff with the required competence, within the user’s organization or externally, to carry out the tasks specified.

The user may wish to seek guidance on this matter from the manufacturer or installer.

All items inspected should be recorded in the system log where applicable (Appendix J).

The system register shall be updated when any major item of equipment is repaired or replaced (Appendix I).

The table which follows is intended to indicate how to maintain a complete refrigeration system in good operating condition. It is not intended as a guide to Statutory Safety Inspections.

Suggested schedule of major and routine inspections

<table>
<thead>
<tr>
<th>Item</th>
<th>Major Inspection</th>
<th>Routine Inspection</th>
<th>Schedule including rectifying faults as necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Annually</td>
<td>Weekly</td>
<td>Check for correct ammonia charge including liquid levels</td>
</tr>
<tr>
<td></td>
<td>Weekly</td>
<td>Check and record operating pressures and temperatures and compare with commissioning logs for significant deviations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly</td>
<td>Leak test system. Record ammonia added or removed and disposal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly</td>
<td>Analyse heat transfer fluids and adjust concentrations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Inspect and clean oil filters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Examine all control and isolating valves for full/free travel, check for leakage and repair valve glands as required</td>
<td></td>
</tr>
<tr>
<td>Pipework</td>
<td>Annually</td>
<td>Weekly</td>
<td>Check for undue vibration, rectify as necessary</td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Inspect for damaged insulation/vapour seal, rectify as necessary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Inspect for evidence of oil at joint locations, rectify as necessary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Inspect pipework for corrosion, rectify as necessary</td>
<td></td>
</tr>
<tr>
<td>Pressure vessels and heat exchangers</td>
<td>Annually</td>
<td>Monthly</td>
<td>Check external surface for corrosion/protective coating damage</td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Check insulation and vapour seal for damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Check fan sequence, condition and tension of drive belts, unobstructed air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Check pumps, condition and tension of drive belts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly</td>
<td>Check condition and operation of defrost heaters</td>
<td></td>
</tr>
</tbody>
</table>

Cont./
<table>
<thead>
<tr>
<th>Item</th>
<th>Major Inspection</th>
<th>Routine Inspection</th>
<th>Schedule including rectifying faults as necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressors</td>
<td>Annually</td>
<td>Weekly</td>
<td>Inspect for evidence of oil leakage including shaft seals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weekly</td>
<td>Check oil levels. Record oil added or removed and disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monthly</td>
<td>Check joints and connections for tightness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Check drive alignment, belt or direct drive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Ensure drive guards are effective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Examine drive belts or direct drive couplings for wear and vibration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Check operation of oil cooler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Check and ensure correct operation of crankcase heaters, if fitted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Check condition of anti-vibration mountings &amp; holding down bolts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Examine for undue noise, vibration or overheating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Change oil or as recommended by manufacturer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Examine oil filters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Sample oil and analyse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Check starting sequence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Check operation of capacity control system</td>
</tr>
<tr>
<td>Ammonia liquid pumps</td>
<td>Annually</td>
<td>Quarterly</td>
<td>Examine vent lines for corrosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annually</td>
<td>Defrost, dismantle and examine internal working parts annually or as recommended by manufacturer</td>
</tr>
<tr>
<td>Safety controls</td>
<td>Annually</td>
<td>Quarterly</td>
<td>Check settings and operation</td>
</tr>
<tr>
<td>Relief device indicator</td>
<td>Annually</td>
<td>Quarterly</td>
<td>Check function</td>
</tr>
<tr>
<td>Relief valve outlets</td>
<td>Annually</td>
<td>Quarterly</td>
<td>Check venting clear and to safe place</td>
</tr>
<tr>
<td>Electrical control panels</td>
<td>Annually</td>
<td>Annually</td>
<td>Visually check condition, including signs of overheating, of all components. Repair or replace as necessary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarterly</td>
<td>Check tightness of all terminals</td>
</tr>
<tr>
<td>Electrical components</td>
<td>Annually</td>
<td>Annually</td>
<td>Check integrity to seals of components</td>
</tr>
<tr>
<td>High / Side Bursting discs</td>
<td>Every 5yrs</td>
<td></td>
<td>Replace as stated</td>
</tr>
<tr>
<td>Low / Side Bursting discs</td>
<td>Every 5yrs</td>
<td></td>
<td>Replace as stated</td>
</tr>
<tr>
<td>Relief valves venting to atmosphere</td>
<td>Every 5 years</td>
<td>Annually</td>
<td>Visual inspection of device and vent line to safe location</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Every 5 years</td>
<td>Replace, or overhaul and recalibrate as stated in PSSR Written Scheme of Examination</td>
</tr>
<tr>
<td>Relief valves venting to low side</td>
<td>Every 5 years</td>
<td>Annually</td>
<td>Annual visual examination where reasonably practicable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Every 5 years</td>
<td>Pressure setting checked every five years</td>
</tr>
</tbody>
</table>
Appendix I – Sample Details for Register

In view of the variety of machinery and equipment used in refrigeration systems and the resultant variation in the type of register suitable for users and their installations, this appendix is for guidance only. It provides an example of a register suitable for pressure vessels.

### Equipment Registration - Pressure Vessels

<table>
<thead>
<tr>
<th>Company</th>
<th>Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Application</td>
</tr>
<tr>
<td>Local Identification</td>
<td>e.g. Works No/ Site No</td>
</tr>
</tbody>
</table>

### Pressure Vessel Details

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Drawing No</th>
<th>Title</th>
<th>Calculations Reference</th>
</tr>
</thead>
</table>

### Design Data

<table>
<thead>
<tr>
<th>Design Code/Categories</th>
<th>Corrosion Allowance</th>
<th>Radiography/NDE</th>
<th>Stress Relief</th>
<th>Strength Test Pressure</th>
<th>Max Allowable Pressure PS</th>
<th>PS x V, Bar Litres</th>
<th>Refrigerant</th>
<th>Design Pressure</th>
<th>Design Temperature</th>
<th>Pressure Relief Devices</th>
<th>Relief Valves</th>
<th>Make</th>
<th>Type</th>
<th>Size</th>
<th>Set Pressure</th>
<th>Discharge capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ammonia</td>
<td>Min.</td>
<td>Min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Max</td>
<td></td>
</tr>
</tbody>
</table>

### Recommended Inspections

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
</table>

### Record of Major and Pressure Systems Safety Regulations: 2000 Inspections

<table>
<thead>
<tr>
<th>Date</th>
<th>Type</th>
<th>Inspector</th>
<th>Report Reference</th>
</tr>
</thead>
</table>

### Record of Examination in accordance with the Written Scheme of Examination as Required by PSSR

<table>
<thead>
<tr>
<th>Date</th>
<th>Type</th>
<th>Inspector</th>
<th>Report Reference</th>
</tr>
</thead>
</table>
### Appendix J - Sample Compressor Operating Data and System Log

#### Name of Site

<table>
<thead>
<tr>
<th>Installation</th>
</tr>
</thead>
</table>

#### System Location

<table>
<thead>
<tr>
<th>System Description</th>
</tr>
</thead>
</table>

#### System Identification

<table>
<thead>
<tr>
<th>Refrigerant Type</th>
<th>Oil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R717 ammonia</td>
<td></td>
</tr>
</tbody>
</table>

#### Operation Log

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Motor Amps</th>
<th>Percentage Capacity</th>
<th>Oil level / Pressure</th>
<th>Hours Run</th>
<th>Leak Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Suction</td>
<td>Discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sat °C</td>
<td>Actual °C</td>
<td>Sat °C</td>
<td>Actual °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### System Location

<table>
<thead>
<tr>
<th>System Description</th>
</tr>
</thead>
</table>

#### System Identification

<table>
<thead>
<tr>
<th>Refrigerant Type</th>
<th>Oil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R717 ammonia</td>
<td></td>
</tr>
</tbody>
</table>

#### Operation Log

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Process Temp</th>
<th>Pressure</th>
<th>Evaporator °C</th>
<th>Condenser °C</th>
<th>Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flow °C</td>
<td>Return °C</td>
<td>Diff</td>
<td>Bar</td>
<td>In</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix K – IOR Policy on Refrigerant Choice

The IOR provides a range of Guidance Notes on the characteristics, design, installation, service and good practice use of all refrigerants. IOR policy is to promote the responsible use of refrigerants, for the public benefit. A responsible refrigerant use policy places a high emphasis on the elimination of leak sources, the efficiency of the overall system and the life cycle cost of ownership.

Refrigerant selection and efficiency

Energy efficiency of refrigeration systems is governed by the laws of physics and by practicality. Practicality embraces cost, cycle, safety, legislative requirements, refrigerant choice and maintenance. Efficiency is not only dependent on choice of refrigerant but also on good design, selection of an appropriate system and good maintenance. Good efficiency is vital to minimize indirect emissions of carbon through energy use.

To maximise efficiency attention needs to be paid to the following:

- Minimising the need for refrigeration and reducing the cooling load. This is the most important first step – a system cannot be considered efficient if the cooling load is unnecessary
- Overall system design. For example the most appropriate cycle, splitting loads at different temperatures onto different suction levels, etc
- Control philosophy. Including the “off-design” operating conditions which are much more common than the peak “design point”, avoiding head pressure control, avoiding partly loaded compressors, avoiding fixed speed auxiliaries like pumps and fans, etc.
- Optimise individual components for efficiency. For example sizing of heat exchangers be, selection of compressor for efficiency etc)
- Operate, monitor and maintain the plant for best efficiency.
Appendix L - Stress Corrosion Cracking

L.1 Introduction

Stress Corrosion Cracking (SCC) is a form of stress corrosion, which results in tiny cracks and has occurred in ferritic steels associated with ammonia containment vessels. In some instances SCC has resulted in catastrophic failures but these major failures, so far as is known at the time of publication, have only occurred in ammonia bulk storage and handling vessels, which are outside the scope of this Code.

SCC can and has been known to occur within refrigerating systems although only isolated incidents have been reported, with ammonia weeping from a crack in the worst case. The problem is sufficiently serious to warrant caution and in respect of this potential hazard some notes are therefore given, based on the limited data on and understanding of the problem to date.

L.2 Occurrence

It is generally accepted that oxygen levels of more than a few ppm in liquid ammonia or a few thousand ppm in gaseous ammonia can promote cracking in steels, therefore care should be taken to ensure the effectiveness of air purging so that contamination by oxygen from the air is minimised.

It is also generally accepted that 0.2% minimum water content in ammonia acts as an effective inhibitor. From random tests it appears that the water level is often below 0.2% on the high-pressure side of the system and above 0.2% on the low-pressure side of the system. Therefore it would seem that the high-pressure side of the system is more at risk than the low-pressure side of the system.

Like most chemical actions SCC will proceed more rapidly at high temperatures, therefore the warmest areas are most at risk and, on the basis of the limited data available to date, SCC is unlikely to occur at temperatures below -5°C.

So far as is known SCC is less likely to occur on vessels that have been manufactured from low strength carbon steel (Re <350 N/mm²) and which have been furnace stress relieved.

L.3 Inspection Surveys

There are major difficulties in inspecting refrigerating system components for stress corrosion cracking. The cracks are very fine and not generally visible to the naked eye; they will occur on the interior of pipes and vessels. It is unlikely that refrigerating systems have or can have adequate access to all internal parts for inspection. In view of these difficulties and because leaks in refrigerating systems due to SCC have been rare and are not known to have resulting in major failure, no requirement is included in this Code for regular inspections.

Where inspections are desired and system construction is such that they can be made, present guidance is that areas of inspection should include cold formed stress areas and weld seams, e.g. at dished end sections of vessels. From K.2 it is obvious that the warm part of the high pressure side of the system is most at risk although it would also be prudent to include vessels on the low pressure side of the system even though the operating temperatures will usually be below 0°C.

Stress corrosion cracking can be detected by external inspection using ultrasonic techniques carried
out by suitably qualified and experienced NDT technicians.

An ammonia sample can be taken from the system and analysed for oxygen and water content. To ensure safety in sampling and meaningful results the ammonia supplier should be consulted on the method to be employed.

L.4 Further Information

All persons with responsibility for refrigerating systems should recognise that present understanding of ammonia induced SCC in steel is incomplete and, although it seems to occur rarely in industrial refrigerating systems, they should be alert to any further information, which may become available and introduce additional inspection or maintenance requirements as appropriate.