# Safe management of ammonia refrigeration systems

## Guidance for the food and drinks industries and other workplaces

Photograph: shows a modern ammonia refrigeration plant room - courtesy of Nestlé UK.

## FOREWORD

This guidance has been developed by industry, following the withdrawal of HSE's publication PM81, to give clear current cross-sector guidance on the safe management of ammonia refrigeration systems. This guidance may go further than the minimum needed to comply with the law.

The guidance was written by the Food Storage and Distribution Federation's Technical and Safety Committee, British Engineering Services, Institute of Refrigeration and other stakeholders, with support from the Health and Safety Executive.

This guidance should be read in conjunction with:

- Safety of pressure systems, the Approved Code of Practice and guidance for the Pressure Systems Regulations 2000 (PSSR)
- Dangerous substances and explosive atmospheres, the Approved Code of Practice and guidance for the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
- The HSE webpages on pressure systems, fire and explosion and DSEAR.

The guidance is also supported by the Air Conditioning and Refrigeration Industry Board (ACRIB) whose members are:

**Full Members**

Federation of Environmental Trade Associations.

Refrigeration, Air Conditioning and Heat Pump Group of Building & Engineering Services Association.

Institute of Refrigeration.

**Associate Members**

Associated Air Conditioning and Refrigeration Contractors.

British Frozen Food Federation.

Cambridge Refrigeration Technology.

Chartered Institution of Building Services Engineers.

Food Storage and Distribution Federation.

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## INTRODUCTION

1. Ammonia[1] has been used as a refrigerant in industrial applications for more than 150 years. It continues to be the refrigerant of choice in many food processing and storage applications, and has seen increased use in building services and process applications. Ammonia is an excellent natural refrigerant and offers a number of significant environmental and operational benefits over its synthetic rivals. Environmentally it has zero ozone depleting potential (ODP) and zero direct global warming potential (GWP).

2. This guidance has been prepared by the Food Storage and Distribution Federation's Technical and Safety Committee (TASC) and RSA Engineering Inspection and Consultancy Services together with the Institute of Refrigeration in consultation with HSE and other industry stakeholders. It applies to new and existing installations (whether permanent or temporary) and indicates the precautions a risk assessment would identify as reasonably practicable to achieve compliance with the detailed legal provisions. While the general approach will apply equally to existing and new installations, it may not always be reasonably practicable to make changes to some engineering controls or modify the plant at some existing systems. The risk assessment will identify this and the appropriate risk management procedures to be applied in these circumstances. The controls would be expected on new plant. This guidance applies to industrial and commercial refrigeration plant in the food and drinks industry and is relevant for applications in other workplaces, for example ice-rinks and the petro-chemical industry. It does not cover domestic or transport refrigeration.

## THE HAZARDS OF AMMONIA

3. Ammonia is a gas with a distinctive pungent odour which can normally be detected by smell at concentrations as low as 5 parts per million (ppm). Higher concentrations are easily detected. It is colourless, lighter than air and chemically reactive.

4. The acute toxicity of ammonia is a major consideration in the safe design and operation of refrigeration systems. Although the odour of ammonia can be detected by smell at concentrations above 5 to 10ppm people who are used to it can work without discomfort in concentrations of approximately 100ppm. Concentrations between approximately 150ppm and 200ppm will cause irritation of the mucous membranes and the eyes, but normally with no lasting consequences. From approximately 500ppm to 700ppm, the eyes are affected

[1] Throughout this guidance 'ammonia' means Anhydrous Ammonia used as a refrigerant.
Anhydrous Ammonia has been assigned the unique Chemical Abstracts Service (CAS) registration number 7664-41-7. It is also commonly referred to by its ASHRAE refrigerant classification, R717.
ASHRAE - (Formerly the American Society of Heating, Refrigerating and Air Conditioning Engineers), founded in 1894, is a building technology society with more than 50,000 members worldwide.

more and more quickly, streaming with tears after 30 seconds or less, but the air is still breathable.

5. At approximately 1000ppm, breathing is intolerable and vision is impaired but not lost. Eye injuries constitute the most serious hazards at this concentration in terms of possible permanent disability. Exposure to concentrations of approximately 1500ppm and above will damage or destroy tissue, and the instant human reaction, even for trained people, is to quickly evacuate the area. Concentrations of approximately 2500ppm and above will rapidly increase the risk of fatality.

6. It should be noted that the effect of ammonia is a function of concentration level and length of exposure time. Higher concentrations can be tolerated for short periods but the effect of ammonia breathed into the lungs or in the eyes can persist for long periods after the person affected has returned to an area where there is fresh air. All of the acute toxic effects of ammonia are due to the removal of water from affected tissue, which is why even small liquid splashes can cause permanent damage. There are no chronic toxicity effects of ammonia. The work place exposure limits (WELs) have been set to protect workers from both long-term and short-term effects of exposure to ammonia. The 8-hour time weighted average (TWA) is 25ppm and the short-term limit measured over a 15 minute reference period is 35ppm.

7. Ammonia forms a flammable atmosphere at concentrations between 16 and 25% by volume in air.

8. Ammonia suppliers have a requirement to classify the product, provide hazard information (safety data sheets) and provide safe packaging in accordance with the CLP Regulations[2] (see http://www.hse.gov.uk/chemical-classification/legal/clp-regulation.htm for further information). The intention of the CLP Regulation is very similar to the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 which they replace – substances and

[2] The European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures – the CLP Regulation – came into force in all EU member states, including the UK, on 20 January 2010. The CLP Regulation:

* Adopts in the EU the Globally Harmonised System (GHS) on the classification and labelling of chemicals;
* Was phased in through a transitional period which ran until 1 June 2015. The CLP Regulation applies to substances from 1 December 2010, and to mixtures (preparations) from 1 June 2015;
* Applies directly in all EU member states. This means that no national legislation is needed;
* Is overseen by the European Chemicals Agency (ECHA);
* Replaced the Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 – CHIP – from 1 June 2015

The intention of the CLP Regulation is very similar to CHIP – substances and mixtures that are placed on the market should be classified, labelled and packaged appropriately. But because CLP adopts the GHS, in time, the same classifications and labelling will be used throughout the world.

mixtures that are placed on the market should be classified, labelled and packaged appropriately.

Ammonia is classified under these Regulations as flammable and toxic, to be labelled with the following hazard statements and precautionary statements[3]

Hazard statement:

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| H280 | Contains gas under pressure; may explode if heated. |
| H221 | Flammable gas. |
| H331 | Toxic if inhaled. |
| H314 | Causes severe skin burns and eye damage. |
| H400 | Very toxic to aquatic life. |
| EUH071 | Corrosive to the respiratory tract. |

Precautionary Statement Prevention:

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| P210 | Keep away from heat/sparks/open flames/hot surfaces. - No smoking. |
| P280 | Wear protective gloves/protective clothing/eye protection/face protection. |
| P260 | Do not breathe gas, vapours |
| P273 | Avoid release to the environment. |

Precautionary Statement Response:

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| P377 | Leaking gas fire: Do not extinguish, unless leak can be stopped safely. |
| P381 | Eliminate all ignition sources if safe to do so. |
| *P303 P361 P353 P315* | IF ON SKIN (or hair): Remove / Take off immediately all contaminated clothes. Rinse skin with water/shower. Get immediate medical advice/attention. |

[3] Although the CLP hazard pictograms are very similar to the CHIP hazard symbols, they have a new shape, new design and a new colour. CLP hazard statements replace CHIP risk phrases and CLP precautionary statements replace CHIP safety phrases.

| | |
|---|---|
| P304<br>P340<br>P315 | IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get immediate medical advice/attention. |
| P305<br>P351<br>P338<br>P315 | IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get immediate medical advice/attention. |

Precautionary Statement Storage:

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| P403 | Store in a well-ventilated place. |
| P405 | Store locked up. |

Precautionary Statement Disposal:

None

## THE RISKS FROM AMMONIA REFRIGERATION SYSTEMS

9. In most staffed situations it is the toxic effect which is most important as ammonia has toxic effects at levels much lower than the minimum flammable concentration. However, precautions against fire and explosion effects still have to be taken – especially for un-staffed parts of the installation.

10. The HSE has in the past identified common failures in the understanding of ammonia refrigeration technology in some designers, installers, contractors and site staff. These include:

    * A lack of understanding of the science of ammonia refrigeration and the implications for design and modification.
    * Failure(s) to select, install, maintain, check and use systems correctly.
    * Failure(s) to identify through assessment the likely sources of gas escape so that appropriate plant modifications may be made or appropriate plant checks instituted to detect likely sources of leakage at an early enough stage.
    * Failure(s) to prepare and rehearse emergency procedures to limit the effect of leakage if one occurs.
    * Failure(s) to train personnel.

## MANAGING THE RISKS

11. The Management of Health and Safety at Work Regulations 1999 (The Management Regulations) require employers to make and implement effective arrangements for assessing the risk and planning, organising, controlling, monitoring and reviewing the preventive and protective measures necessary to

meet the specific requirements contained in relevant health and safety regulations.

12. For ammonia systems these requirements are contained mainly in the Provision and Use of Work Equipment Regulations 1998 (PUWER), the Pressure Equipment Regulations 1999 (PER), the Pressure Systems Safety Regulations 2000 (PSSR) and the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). However, this list is not exhaustive and in some instances other regulations may also apply.

13. The PSSR sets out exceptions for vapour compression refrigeration systems having a total installed power of less than 25kW. However, in such cases the general provisions of PUWER, The Management Regulations and the Health and Safety at Work etc. Act 1974 (HSWA) shall still apply.

14. The reader should ensure that all these regulations are understood and their requirements are accounted for when the guidance is applied.

15. Experience of past incidents involving ammonia refrigeration systems has shown that the overall arrangements to manage such systems must be improved. Further, it has been concluded that training is the common factor to improving the safety record for ammonia refrigeration:

- Training system specifiers to ensure they are competent and fully appreciate the risk consequences of their decisions.
- Training designers to understand how to eliminate or minimise risks is perhaps the most potent improvement that can be made.
- Training operators and maintenance technicians to avoid errors that could cause them serious injury or in the worst cases cost them their life.

**IDENTIFYING THE RISKS AND MEASURES NEEDED**

16. This is an important requirement of key significance for ammonia refrigeration systems. The assessment shall identify where significant risks arise from the plant and identify the measures necessary to comply with statutory provisions. The significant risks are likely to be those where a gas escape could occur if a single reasonably foreseeable fault occurs, for example, a single plant failure or an operator fault when performing a critical task.

17. The risks can be summarised as follows:

(a) Ignition of a flammable gas in the event of a fire.

(b) Ignition of an explosive mixture of ammonia and air causing a building collapse (or similar event to occur).

(c) Contact with the volatile liquid causing tissue damage to eyes, nose, skin, lungs etc.

(d) The breathing of the toxic gas causing respiratory failure.

(e) Unpredictable behaviour (especially when operatives lack training or where members of the public are involved).

Risks (a) and (b) generally exist only in the 'near field', i.e. close to the point of leakage and are generally dealt with in the case of catastrophic failure by adherence to the requirements of BS EN 378 in the machinery room areas. In the case of failure during normal operation conditions this is dealt with by hazardous area classification and adherence to the requirements of DSEAR.

Risk (c) and (d) generally only apply to personnel who are working on, i.e. maintaining, the refrigeration systems. These risks are dealt with by the development of appropriate risk assessments and safe systems of working (or method statements) for any work that may expose personnel to the risks and ensuring the use of appropriate PPE, i.e. impervious clothing and gloves, use of goggles, use of or access to canister type respirators, etc.

Risk (e) is the most problematic since it is difficult to predict how people (especially the public) will react in the event of an ammonia release.

18. Ammonia does not present any risk of toxicity or flammability while it is contained within the pressure system. Trace quantities of ammonia are released to atmosphere during routine maintenance. In particular, it is important to ensure that oil samples (including oil drained for disposal) are thoroughly ventilated to atmosphere before the oil container is sealed for transport. In abnormal conditions ammonia could be released for example due to a component failure or if the system pressure rose to a level higher than the set value of the relief device causing a relief valve to lift and the ammonia to disperse into the external atmosphere.

19. Appendix 1 covers the significant risks associated with simple systems. This information is based on past experience of what has gone wrong in practice and in many cases consideration of these identified risks should satisfy the requirement for assessment.

20. However, where the risk is higher, more detailed assessments are needed. Higher risk situations could include for example:

* Off-site consequences due to the close proximity of other people for example, those working in adjacent industrial units, hospitals, nursing homes or residential estates, and those travelling on transportation systems (such as roads and railways),
* Larger quantities of ammonia retained in installed systems
* Ammonia refrigerant is circulated directly around workrooms.

21. In such circumstances a more formal and critical assessment shall be made. Such an assessment would be similar to a hazard and operability study for chemical process plant (HAZOP).

22. Ammonia refrigeration systems holding 50 tonnes or above are subject to the Control of Major Accident Hazards Regulations 2015 (COMAH) and require the occupier to positively demonstrate that it can be run safely. In the majority of

cases COMAH is unlikely to apply however the EEMUA Publication 231 – Ed 1, SAFed Publication IMG 1 (see Appendix 5 for further details) does provide guidance concerning the periodic examination and testing of plant containing hazardous substances to maintain its mechanical integrity that can be referred to when considering the risks of ammonia systems that are below the COMAH threshold.

23. Safety critical items of plant or tasks where single faults in plant or procedures would result in gas escape, despite the existing controls shall be identified for priority attention. Additional preventive or precautionary measures necessary to prevent gas escape shall also be included to the extent that they are reasonably practicable. Appendix 1 identifies these factors and measures for simple systems. In most cases engineering solutions such as the installation of double valves on oil drains or the installation of oil drain pots would be appropriate, but in others safe systems of work or instructions on what to do in the event of abnormal or emergency circumstances may be appropriate. For many risks, early detection of incipient faults through targeted maintenance checks will be most appropriate. The other sections of this guidance indicate the wide variety of controls which should be required, ranging from examination of plant to training and informing operators. Where these precautions are reasonably practicable and would improve health and safety, they are a requirement.

24. The significant findings from the assessment of risk must be recorded if five or more people are employed – they could form part of the general health and safety arrangements included in the safety policy document.

25. Ammonia is classified as dangerous for carriage and should be transported in accordance with the requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009.
Further guidance can be found on HSE's carriage of dangerous goods webpages (see http://www.hse.gov.uk/cdg/).

## SELECTION OF PLANT

26. The selection of plant shall be suitable in respect of any reasonably foreseeable health and safety risks. Initial integrity, the place where it is to be used and its purpose all need to be addressed. New ammonia refrigeration systems shall be specified to comply with all current regulations such as PUWER, PER, PSSR, and DSEAR. In addition, plant should also comply with the requirements of BS EN 378 Refrigerating systems and heat pumps. Safety and environmental requirements - Parts 1-4 (or an equivalent international standard), as well as the guidance published by the Institute of Refrigeration: Safety Code of Practice for Refrigerating Systems Utilising Refrigerant R-717 (Ammonia).

27. In addition, since July 2006 all older ammonia refrigeration systems must comply retrospectively with DSEAR.

28. Older ammonia refrigeration systems should comply with the relevant previous versions of BS EN 378 or the relevant version of the previous standard BS 4434 -

Safety Aspects in the Design, Construction and Installation of Refrigerating Appliances and Systems last published in 1995, as well as the relevant version of the Institute of Refrigeration guidance. However, older systems shall be upgraded where reasonably practicable[4].

29. **Location:** consider locating the plant in a separate building from the main store or workroom. For standard refrigeration plant, where reasonably practicable, compressor houses should be sited so as to allow the necessary ventilation and explosion relief (for example the roof or one wall being external). If plant is located outdoors, or if indoor plant is likely to be subjected to low ambient temperatures, then it shall be designed to avoid problems associated with maximum and minimum ambient temperatures, both during normal operation and when the system is not running. There should be no openings that permit passage of leaked refrigerant into other parts of buildings. Doors between plant rooms and other parts should be self-closing and well-fitting to prevent the spread of vapour.

30. **Purpose:** the amount of plant containing ammonia situated in workrooms should be minimised, as should the amount of ammonia: low charge systems are available. The risks can also be reduced by removing valve stations from occupied areas or roof voids to outdoors, so that all indoor, ammonia containing elements are fully welded with no or minimal potential leakage routes. In addition, indirect plant using for example, 'brine' or liquefied carbon dioxide, for circulation around workrooms and shops will have an inherently lower risk than systems directly circulating ammonia. If ammonia is to circulate around workrooms or stores, then the risk assessment shall determine the extent of precautions for maintenance, monitoring and ventilation that are required throughout the entire system and not just in the compressor room. If direct acting evaporating plant such as tunnel freezers is necessary, then ancillary plant such as surge drums and liquid pumps should be sited away from populated workrooms. Emergency procedures are especially important in these circumstances and adequate emergency exits must be maintained at all times.

## INSTALLATION OF PLANT

31. The installation of plant should be in accordance with the standards given above and the design and construction shall meet the requirements of PER and Regulations 4, 5 and 6 of PSSR. The Approved Code of Practice (ACoP) to those Regulations gives design details as an indication of how to meet these requirements including 'nothing about the way in which it is installed' should cause danger.
It is important to consider the containment of liquid ammonia should a leak occur for example the installation of retainment bunds under storage vessels.

32. For all refrigeration systems with a total installed power of 25kW or more, the user shall ensure to comply with PSSR and that a Written Scheme of Examination

[4] Systems installed prior to July 2003 must now comply retrospectively with the requirements of DSEAR 2002 from July 2006.

(WSE) is prepared by a competent person and any inspections required by the WSE must be completed prior to the system being first brought into use (PSSR Regulations 7, 8, 9, 10, 11, 12, 14 and 15).

33. For refrigeration systems with a total installed power of less than 25kW a WSE is not required although other section of PSSR still apply (PSSR Regulations 7, 11, 12 and 15).

34. In both cases the designer or supplier shall give the user and the competent person sufficient written information concerning the plants design, construction, examination, operation and maintenance as may reasonably be necessary to enable the user to continue to operate it safely. It is recommended that a laminated copy of the refrigeration circuit diagram be displayed in the machinery room.

## MODIFICATION AND REPAIR

35. The employer of a person who modifies or repairs a pressure system at work shall ensure that nothing about the way in which it is modified or repaired gives rise to danger or otherwise impairs the operation of any protective device or inspection facility (PSSR Regulation 13).

36. Modifications or repairs shall take in to account the original design specification, the duty after repair or modification, the effect of the work on the integrity of the system, adequacy of protective devices and the continued suitability of the WSE must be confirmed or suitably modified by the competent person before the system is returned to service. In particular:

   * All repair and modifications shall be carried out to the appropriate unified codes/standards that apply to the system.
   * Non-Destructive Examination (NDE) shall be carried out in accordance with the relevant code(s).
   * Site welds shall be tested in accordance with the relevant code(s) but in all instances it is recommended as best practice not less than 10% or a minimum of at least 2 butt welds.
   * It is recommended as best practice that NDE shall consist of both volumetric and surface breaking tests.

## SAFE OPERATING LIMITS

37. ‘Safe operating limits’ means the operating limits (incorporating a suitable margin of safety) beyond which system failure is liable to occur. They are the limits beyond which the system shall not be taken. They are not the ultimate limits beyond which system failure will occur. In establishing the limits within which a system shall be operated, there may be a need to take account of matters other than pressure energy and the likelihood of system failure.

38. The safe operating limits for the plant must be established by the user/owner before the system is first operated. The maximum and minimum design pressures for the system shall be stated. The maximum pressure may be different for the high, intermediate and low pressure parts of the system. Although the pressure may sometimes be expressed as equivalent condensing or evaporating saturation temperature, to avoid confusion it is essential that pressure limits are stated in appropriate units of pressure (for example, bar(g) or psi). This information will normally be supplied by the manufacturer, installer or repairer but must be approved and incorporated in the WSE by the competent person.

39. Where the plant has been specified and supplied to the industry standards identified above, then the limits may be known from the design criteria. However, where this is not the case a competent person may have to be engaged to assess the individual components of the whole plant and set the safe operating limits.

40. The maximum allowable operating pressure for any part of the system must not be greater than the lowest maximum allowable operating pressure of any component in that part of the system.

## MAINTENANCE

41. The plant must be maintained 'in efficient working order and in good repair' (with respect to health and safety risks). The risk assessment will have identified the safety critical features of the plant and the controls identified to safeguard these risks shall be subject to targeted maintenance and checked as often as experience indicates necessary to detect early warning signs of potential problems. This shall include checking and recording the operation of safety-related devices such as emergency detection alarms and ventilation devices and safety valves. A recommended schedule for inspection and maintenance is at Appendix 3. See also any manufacturers'/suppliers' own published recommendations/instructions.

42. For PSSR qualifying systems, the type and frequency of maintenance and inspection for the system shall be assessed. It is recommended that a maintenance log be retained and kept up to date.

43. Inspection of the plant shall be undertaken by someone with sufficient competence, experience, training and understanding to identify what may be the early stages of faults developing, so they can be remedied before failure.

## EXAMINATION

44. For PSSR qualifying systems, the plant must not be operated unless the user has a WSE for its periodic examination, written by a competent person covering:

- All protective devices, for example high pressure cut-outs, pressure relief valves and bursting discs;

- Every pressure vessel and heat exchanger; and
- All parts of the pipework in which a defect may give rise to danger

Such parts shall be identified in the WSE.

Notwithstanding the requirements of PSSR it is recommended that the overall refrigeration system, including compressors, condensers, evaporators and associated components be regularly maintained and periodically inspected by a competent person to ensure:

- Planned Preventative Maintenance (PPM) procedures conform with the manufacturer's recommendations
- All PPM activities are up to date
- Protective devices are correctly installed and functioning
- There are hard-wired high level cut-outs installed
- Functional tests are regularly carried out to confirm the correct operation of protective devices
- Operational log sheets are up to date

45. It is the responsibility of the user/owner to select a competent person capable of carrying out the duties in a proper manner with sufficient expertise in the particular type of system. In some cases, the necessary expertise will lie within the users'/owners' own organisation (see in addition paragraph 59 below for guidance on the independence of the competent person). In such cases, the user/owner is acting as competent person and is responsible for compliance with the Regulations. However, small or medium-sized businesses may not have sufficient in-house expertise. If this is the case, they shall use a suitably qualified and experienced independent competent person. Whether the competent person is drawn from within the user's/owner's organisation or from outside, they shall have sufficient understanding of the systems in question to enable them to draw up schemes of examination or certify them as suitable.

46. The WSE is the responsibility of the user/owner and may be drawn up by the user or installer provided that the scheme is checked and certified as being suitable by a competent person. Alternatively, the competent, trained person can draw up the WSE (PSSR Regulation 8).

47. As the age of the plant increases or other factors intervene, the system may for example degrade more quickly. To mitigate this, the WSE shall be reviewed by the competent person to ensure that the scope and frequency of inspection remain appropriate. It shall be noted that the competent person shall, in any event, confirm after each examination that the WSE still remains valid (or detail, as necessary, any required amendments).

48. If the competent person carrying out an examination in accordance with the WSE is of the opinion that the system or part of the system will give rise to imminent danger unless certain repairs or modifications have been carried out or unless suitable changes to the operating conditions have been made, then he or she shall

immediately make a written report to that effect identifying the system and specifying the repairs, modifications or changes required (PSSR Regulations 9 and 10).

49. Where repairs or modifications have been carried out the system must be examined by a competent person in accordance with the WSE (and where appropriate any revision to the WSE) before the system is taken back into operation for the first time.

50. Operators shall also ensure additional inspections are undertaken where parts of the system are excluded from the WSE, if those parts of the system are liable to deterioration and their failure could result in a loss of containment of ammonia that in turn could result in a dangerous situation. For example, failure in the mechanical integrity of pipework is frequently the cause of ammonia leaks.

## EMERGENCY ARRANGEMENTS

51. The employer (normally the person who owns the system) will have to establish emergency arrangements to be followed in the event of ammonia escape. These must cover especially the provisions for detection of ammonia escape, raising the alarm, emergency venting of plant and isolation of electrical appliances (if adequate ventilation is not provided to keep below the lower explosive limit) as well as closing valves to isolate the system into smaller sections and to prevent further escape.

52. The risk assessment shall determine the personal protective equipment likely to be needed for access and rescue, bearing in mind the response time of the local Fire Brigade may mean immediate emergency entry, for example for rescue may be needed.

53. For those entering the plant:

    * They should have on-person suitable emergency self-rescue breathing apparatus (EBF); and
    * They must be trained and drilled and competent in its correct use.

54. In addition, other early warning systems to be carried by the person (for example ammonia detection and warning) should be considered. When in use, the wearer should be instructed that EBF is only for emergency self-rescue and not for work (e.g. staying inside and trying to seal a leak).

55. Systems for communication (including where lone workers are involved) should be addressed. Just having an EBF and ammonia monitor on the person and fixed monitors are not good enough. Communications systems/alarms and procedures covering how and when to respond should also be in place.

56. Procedures for evacuation of the remaining people likely to be affected shall be prepared and the information passed to the relevant competent, nominated person.

57. Well thought out and rehearsed emergency plans with properly trained and equipped staff and with safe, quick access to essential control valves whose function is clearly identified, is a major factor in containing a gas escape

58. EN 378-3, Clause 7.4 requires the user/owner to ensure that in the case of ammonia systems with charges above 3,000kg that a permanently attended station is 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 technical equipment e.g. mobile telephone, pager etc.

59. Employers, in addition to their own employees, must also assess the risks to health and safety of anyone else who might be affected by an ammonia gas release. This is important because in many cases the danger could extend well beyond the boundary of the site containing the ammonia refrigeration system. See Appendix 5 for further advice regarding accidental releases of ammonia and toxic levels of concern.

## ENVIRONMENTAL PERMITTING REGULATIONS 2010

60. Ammonia refrigeration plants do not require an environmental permit in their own right. However, when their use is directly related to another activity that is covered by the Environmental Permitting Regulations (EPR) for example, food and drink manufacturing and slaughterhouse operations (above a specified threshold) the refrigeration plant will be included as part of the EPR permit.

61. Notwithstanding the above, there is a general obligation under EPR for operators to use 'Best Available Techniques' (BAT) to prevent, reduce or eliminate pollution and there are also other requirements that include for example the efficient use of energy. Whilst specific permit conditions for refrigeration plant may not be included it is recommended that an operator should be able to nevertheless demonstrate they are employing BAT.

62. Further guidance regarding EPR may be obtained from the Department for Environment, Food and Rural Affairs (Defra).

## ORGANISATION OF THE MEASURES

63. Arrangements are required to be put in place with the necessary structure for example to the aspects identified in paragraphs 60 to 64

## APPOINTMENT OF COMPETENT ASSISTANCE

64. The employer shall appoint a person competent to assist in undertaking the measures he or she needs to take to comply with all the legal requirements the necessary assessment identifies to be relevant.
The degree of knowledge about refrigeration needed by people assisting will depend on the risks.

For simple installations familiarity with guidance (such as this) by a member of staff might be sufficient if they have the ability to implement it. For more complex risks the employer should consider external assistance such as specialist consultants. A refrigeration contractor engaged to operate the plant on behalf of the employer might also be competent to fulfil this role. However, the competent assistance required shall be distinguished from the narrower definition for certain tasks in PSSR that must be approved and certified by a 'competent person'

**CO-ORDINATION**

65. The employer must ensure the legal duties are met even if he or she delegates their execution to a contractor. There is a particular need to agree who is the 'user' with obligations under the PSSR in the event of a contractor commissioning and/or running the refrigeration plant. Appendix 4 contains the text of a statement agreed with the industry that should, dependent upon circumstances that exist for the actual ammonia refrigeration system in question, be suitable for this purpose.

66. The responsibilities of various staff and other parties as they apply to the refrigeration system should be detailed to avoid confusion and ensure all aspects are covered. The employer must also inform the safety representatives of any arrangements and training proposals as they can play an important part in managing the risks.

**COMMUNICATION AND RECORDS**

67. Retaining records will assist the competent person in the examination under the WSE. The purpose being to assess whether the system is safe for continued use and/or if any planned repairs or modifications can be carried out safely. The user/owner shall keep the following documents readily available (PSSR Regulation 14):

- The WSE (in either hard copy or electronic format)
- Designer's/manufacturer's/supplier's documents relating to parts of the system included in the WSE
- Documents pertaining to the design, manufacture and conformity of equipment supplied and put in to service under the Pressure Equipment Regulations 1999
- The most recent examination report produced by the competent person under the WSE
- Any agreement or notification relating to postponement of the most recent examination under the WSE
- All other reports which contain information relevant to the assessment of matters of safety, for example the maintenance log book.

## COMPETENCE

### General

68. Employers, owners and users shall take all reasonably practicable steps to ensure they are engaging only competent designers, maintenance contractors etc. and to ensure, so far as is reasonably practicable, the competence of their own staff operating the plant.

### People using the plant: (operating, checking, maintaining, servicing, repairing and modifying)

69. These people shall be provided with adequate health and safety information on the risks, the precautions at the plant and written instructions of any safe systems of work, the safe operating criteria and limits, action to be taken in foreseeable abnormal situations and action to be taken in an emergency. Similar information shall be available to those who manage or supervise such staff. For further information, refer to BS EN 13313:2001.

70. Before entrusting tasks at such plant to employees (or others) the employer must take into account their capabilities as regards health and safety and ensure they are adequately trained. Employees shall only use the plant in accordance with instructions given and shall report any situations which they consider represent a (serious or immediate) danger to health and safety or any shortcoming in the employer's protection arrangements to the appropriate person.

71. Training and competence requirements are particularly important with respect to those who do repair or modification work on systems. Ammonia systems require specialist knowledge. There are no particular qualifications prescribed in UK law to define appropriate levels of competence in these various tasks.

72. However, the Air Conditioning and Refrigeration Industry Board (ACRIB) have developed in conjunction with City and Guilds a vocational award in handling refrigerants (see http://www.acrib.org.uk/PLB4BT47732 for further information). However, this is only one measure of competence – those engaging personnel to maintain and service ammonia plant should ask for confirmation of the competence, including current records of the training they have undertaken.

73. In particular, it should be noted that BS EN 60079-17 Explosive atmospheres. Electrical installations inspection and maintenance, requires that the inspection and maintenance of electrical installations in potentially explosive atmospheres is only carried out by suitably experienced and trained personnel.

### People undertaking risk assessment

74. The employer is likely to need assistance in undertaking the risk assessment and in deciding on and implementing the subsequent preventive and protective measures. This could be by the person appointed as the competent assistance (see above).

However, for more complex plant, the degree of competence necessary is likely to indicate that specialist assistance is necessary, for example from the manufacturers or installers or specialist consultants.

**People preparing written schemes of examination**

75. The owner or user has to ensure the competent person drawing up, or certifying or examining under a WSE is in fact competent. The Approved Code of Practice (ACoP) L122 for PSSR provides an indication of criteria of competence. The attributes and role of competent persons and their required competences are explained in paragraphs 97-99 of the ACoP. Either 'intermediate' or 'major' systems are the most appropriate to ammonia refrigeration systems. Such people are likely to be found in refrigeration plant manufacturers and specialist consultancies.

**People carrying out the examination**

76. The competent person who carries out the examinations must have such practical and theoretical knowledge and actual experience of the type of system to enable defects and weaknesses to be detected in relation to their importance to the integrity of the system. Again, such people are likely to be found in refrigeration plant manufacturers and specialist consultancies.

## CONTROLLING THE MEASURES

77. Arrangements are required to ensure the decisions and measures identified by the planning process are in fact, implemented as planned, for example thorough supervision and reports.

## MONITORING AND REVIEWING THE MEASURES

78. Procedures are required to develop and improve the overall arrangements, in the light of feedback as to their effectiveness. Information should therefore be recorded to enable that review to take place, for example monitoring inspections, maintenance, evacuation procedures etc.

## APPENDIX 1 – SAFETY CRITICAL ASPECTS OF AMMONIA REFRIGERATION SYSTEMS

### Installation

1. The amount of plant containing ammonia situated in workrooms should be minimised, as should the amount of ammonia: low charge systems are available. See paragraph 29 of the main guidance.

2. Corrosion due to condensation can progress rapidly on the external surfaces of the plant where they are below the prevailing dew point temperature. This may include parts which run intermittently and pass through $0^{o}C$ (zero degrees centigrade), for example on low pressure parts, and under lagging which has not been adequately vapour sealed. Areas which operate continuously below freezing are less likely to suffer from significant corrosion.

3. All pipework containing ammonia shall be identified[5] by colour coding or labelling and positioned and protected to prevent damage. It is good practice to uniquely identify part of the system that contain gas or liquid and the direction of flow.

4. High level alarm switches shall be fitted to all intercoolers and surge drums to monitor high levels of ammonia liquid. They should also be arranged to protect compressors from ammonia liquid carry over.

5. Isolation valves should be easily accessed and clearly identified for use during an emergency.

### Ventilation

6. Machinery rooms should be provided with sufficient permanent ventilation during normal operations to prevent the build-up of toxic concentrations of ammonia from any small operational releases (for example from seals, glands etc.). This can be achieved by mechanical ventilation or from inlet louvers or air bricks in external walls fitted at low level with vents at high level to facilitate natural circulation.

7. Additionally, emergency ventilation linked to gas detectors should be provided in machinery rooms to protect against explosion risks. Detectors should be strategically located and arranged to automatically switch on the mechanical ventilation and shut down the plant together with any unprotected electrical equipment. The ventilation system should be suitable for use in a Zone 2 hazardous area.

8. The emergency ventilation shall be designed to prevent flammable ammonia and air mixtures accumulating in the event of reasonably foreseeable plant or operational failure, for example valve failure.

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[5] The Health & Safety (Safety Signs and Signals) Regulations 1996 apply to the labelling of containers, pipework etc.

The arrangements shall keep the concentration below 20% of the lower explosive limit (LEL) as set out in BS EN 378:2008. The ventilation shall discharge to a safe place – for example, by taking pressure relief valve and ventilation system discharges to as high a point as reasonably practicable and pointing them vertically upward provides a major benefit in risk reduction, as ammonia vapour dispersion is significantly improved - and also not where it might be drawn into other parts of the building through openable windows or ventilation inlets.

BS EN 378:2008 Part 3, Section 8.7 states that for control purposes where the charge size is more than 50 kg, an R717 detector(s) is required which shall function at a concentration not exceeding:

- 350mg/m3 (500ppm (V/V) or equivalent to 0.33% LEL) in machinery rooms (pre-alarm) that shall activate an alarm and automatically start the emergency ventilation;
- 21,200mg/m3 (30,000ppm (V/V) or equivalent to 20.00% LEL) (main alarm) that shall isolate all electrical equipment that is not specified for use in a Zone 2 hazardous area.

However, it is practical and considered best practice to activate the pre-alarm at the lowest level that does not result in too many false alarms and the main alarm at a level no greater than 7,067mg/m3 (10,000ppm (V/V) or equivalent to 6.67% LEL).

9. Failure of the mechanical ventilation system should initiate an alarm so that corrective action can be taken.

10. Vents from relief valves shall be directed to a safe place. BS EN 378-3:2008 recommends that refrigerant should be prevented from entering neighbouring rooms, staircases, courts, gangways or building drainage systems and the escaping gas shall be vented outdoors. There should be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed to prevent any refrigerant leakage from entering the air stream.

11. Minimise points where the system can relieve to atmosphere. Some major plants incorporate a step or cascade of high pressure cut out relief to suction where appropriate and then relieve to the atmosphere to minimise risk of emissions.

**Oil draining**

12. An appropriate operating procedure in relation to valve closure sequence can eliminate the need for a bleed or relief valve.

13. Oil drains shall be designed to be as compact as possible, ensuring that adequate observation of the drain can be achieved and with the termination in a safe location. BS EN 378-4 Annex A allows oil draining in an effectively vented (ventilated) room. Valves on any pipe extension should not allow the possibility of liquid ammonia being trapped; a bleed valve or hydrostatic relief valve venting to a safe place should be provided in the section between valves, as appropriate.

14. It is preferable to use oil drain catch pots. These are a useful feature on new plant, but existing plant may be difficult to modify. Before the oil is drained, the catch pot is isolated from the liquid ammonia and oil feed line and the catch pot is electrically or naturally heated to boil off any ammonia, which flows as a vapour to the low pressure side of the system. When the catch pot is warm, it is also isolated on the vapour side and the oil is then drained from it. A drain pot relying on natural heat gain to an un-insulated vessel to heat it is safer than one electrically heated. The pot may also be pressurised with discharge gas when isolated from the liquid ammonia, provided suitable safety measures such as appropriate relief devices are fitted.

15. Alternatively, a double valve arrangement should be provided at oil drains. In addition to the operation of manual valves, there should be an automatic closing spring or weight loaded valve (dead man's handle).

16. Ammonia filling points shall be located in safe, well ventilated positions and away from sources of ignition. Where reasonably practicable they should be situated in the open air and the connection between the ammonia cylinder and the charging point should be via a flexible connection of appropriate quality and its condition checked. The connection should be broken when charging is complete.

17. For further advice, see the Institute of Refrigeration[6] (IOR) Guidance Note 10 Working with ammonia and Guidance Note 17 Maintenance of refrigerating systems containing refrigerant R717 ammonia.

**Maintenance**

18. Regulation 12 of PSSR requires that the user of an installed system shall ensure that the system is properly maintained in good repair, so as to prevent danger. Good documentation with 'as fitted' drawings and design specifications, maintenance schedules, plant logs, operating checklists, material certificates, pressure test certificates and a technical manual are recommended to ensure safe operation and maintenance of the plant as well as compliance with PSSR.

19. Hot work permit-to-work procedures – all likely sources of ignition should be eliminated from the compressor house and the immediate vicinity of externally located plant. Further advice and guidance on permit-to-work systems can be found in the ACoP L138 – DSEAR.

20. Good planned maintenance systems should be instituted especially for all safety devices such as relief valves, pressure switches etc.

21. Non-return valves shall not be relied upon for isolation.

22. Valves which are required for safe operation and maintenance of the system should be periodically checked for effective closure and early signs of defect.

[6] The Institute of Refrigeration, Kelvin House, 76 Mill Lane, Carshalton, Surrey SM5 2JR T: 02086477033 www.ior.org.uk

23. Seals, glands and gaskets shall be regularly inspected, without dismantling.

24. It is recommended that repair work shall only be undertaken to a predefined procedure, approved where appropriate by a competent person or organisation and shall be verified upon completion by a strength pressure test followed by a tightness test. Where feasible it is recommended the repair shall also be verified by suitable NDE.

25. Those undertaking maintenance work (for example. including filling and oil draining) are to have appropriate respiratory protection equipment at the ready around their neck, for example full face canister respirators: (type K usually green canisters). An impervious suit may be required for substantial jobs such as dismantling pipework or other operations liable to release liquid ammonia or substantial quantities of gas. Such work should never be undertaken alone. Adequate means of escape and rescue should always be provided – even and especially from plant rooms designed to be normally un-staffed.

**Emergency procedures**

26. Safety equipment should be located in nearby rooms but separate from the compressor house (machinery room).

27. Emergency plans shall be established to deal with leaks. The risk assessment should identify the control measures necessary in an emergency. These are likely to include, for example instructions to identify the leak and close key valves. Such valves should be marked and identified on drawings. Regular checks of such valves should be undertaken to ensure correct operation. The alarm should be raised automatically or, for staffed workrooms, with activators near work stations. The alarm should be distinguishable from others such as the fire alarm if different procedures are involved.

28. A clear documented emergency procedure should be drawn up which details the precise duties of all staff and arrangements for evacuation, rescue, first aid, resuscitation, plant isolation etc. It is particularly important that evacuation procedures are clearly set out and are regularly practiced. If seasonal or casual workers are employed, they too should be properly instructed. Personnel should be warned not to approach any vapour clouds. Clouds of vapour may often look like steam because of the cooling effect of the released gas. In no circumstances should entry be made into areas where a flammable concentration of gas is likely to exist.

29. Those entering an area where ammonia is likely (for example. rescue or fault finding) should wear appropriate respiratory protective equipment - see paragraphs 52 to 54 of the main guidance.

30. Anyone who is likely to need to use respiratory protective equipment must be properly trained in its use and its limitations. The equipment must be maintained, kept clean and examined at periodic intervals (at least monthly). Appropriate records should be kept.

31. Adequate eye wash bottles and/or warm water showers should be available in all locations where ammonia is handled, because liquid ammonia splashes on the skin can cause chemical or frost burns and even slight splashes in the eyes and cause permanent damage. BS EN 378-3:2008 recommends that at least 50 litres per minute of water between 25$^0$C and 30$^0$C be provided for a minimum duration of 15 minutes. Cold mains water should not be used as this may result in circulatory shock (low blood perfusion). Such facilities should be regularly inspected and eye wash solutions changed in accordance with the manufacturer's instructions.

32. It is recommended that a windsock is installed above the machinery room (or another suitable adjacent location) so that in case of emergency the wind direction can be readily determined.

## APPENDIX 2 – PROTECTION OF ELECTRICAL AND MECHANICAL APPARATUS NEAR AMMONIA COMPRESSORS AND REFRIGERATION PLANT

### Normal Operating Conditions

1 Both new and existing workplaces, where dangerous substances are used, must be assessed and classified into hazardous places (zones) and non-hazardous places in accordance with Regulation 7(1) of DSEAR. Although ammonia is difficult to ignite it is classified as flammable and can give rise to flammable mixtures and hazardous Zone 1 and 2 area classifications.

2 BS EN 60079-10-1:2015 explains the basic principles of hazardous area classification although it contains no specific guidance for ammonia refrigeration systems. Hazardous area classification and in particular the extent of the identified zone shall be carried out by a competent person. The main requirements of hazardous area classification include:

- Identification of places throughout the refrigeration system where explosive atmospheres may occur. Each item of process equipment (for example, tank, pump, pipeline, vessel, etc.) should be considered as a potential source of release of flammable material.
- Determination of the grades of all identified ammonia releases
- Classification of hazardous areas in terms of zones on the basis of the frequency and duration of the occurrence of an explosive atmosphere. Together with the identification of the source of release the determination of the grade of release are basic elements for establishing the hazardous zone types.
- Calculation of the extent of the zone (or the distance) over which an explosive atmosphere exists before it disperses to a concentration in air equal to 50% of its lower explosive limit.

3 The size of hole selected for consideration in leakage calculations is critical. It determines the release rate of the flammable substance and thus eventually the type of zone and the extent of the zone.
Release rate is proportional to the square of the hole radius. The volume of the hazardous zone which arises is proportional to the cube of the hole radius. A modest underestimate of the hole size will therefore lead to a gross underestimate of the calculated value for release rate and zone extent (hazardous range) which should be avoided. Overestimation of the hole size will lead to a conservative calculation which is acceptable for safety reasons, however, the degree of conservatism should also be limited because it eventually results in overlarge zone extents. A carefully balanced approach is therefore needed when estimating the hole size.

*NOTE: While the term 'hole radius' is used, most unintended holes are not round. In such cases the coefficient of discharge is used as a compensating term to reduce the release rate given a hole of equivalent area.*

For continuous and primary grades of release the hole sizes are defined by the size and the shape of the release orifice, e.g. various vents and breather valves where the gas is released under relatively predictable conditions. Secondary releases only occur under leak conditions and the hole size and shape are therefore less predictable.

4 To comply with the requirements set out in DSEAR electrical equipment within the hazardous zone shall be protected to the appropriate standard for the zone.

5 A hazardous zone from a secondary release may be classified as being of 'negligible extent' (NE) if the volume of the foreseeable gas cloud with an average concentration of 50% LEL can be shown to be less than $0.1m^3$. No action is required to control sources of ignition within an NE zone although it should be noted that limiting parameters may apply to this decision.

6 Paragraphs 1 to 5 above set out the requirements and scope of area classification. It is therefore recommended that in order to avoid over-specifying the extent and type of hazardous areas, this work should be carried out by a competent person or alternatively, specialist advice should be sought.

7 A safe area is an area in which an explosive atmosphere consisting of a mixture with air of gas, vapour or mist is never present.

8 A zone of negligible extent is not the same as a safe area even though neither requires further action with regard to potential ignition sources. In particular, it may be that a zone of negligible extent becomes more onerous if ventilation is reduced during modifications to buildings and housings.

9 The requirement for area classification applies to any parts of the refrigeration system that include sources of release and is not restricted to machinery rooms. Also, it is the possibility of a release of a flammable substance that triggers the requirement of hazardous area classification.

10 Therefore, all machinery rooms and other plant areas containing potential sources of release of ammonia refrigerant[7] shall comply with the requirements of hazardous area classification.

11 The ventilation of machinery rooms shall be sufficient during normal operating conditions and not less than 4 air changes per hour when occupied.

12 Where it is reasonably practicable to do so electrical equipment should be sited outside of any hazardous areas.

<u>Internally-sited plant</u>

13 The operational approaches to prevent equipment giving rise to potential ignition sources are outlined below:

- Areas where there is the possibility of the presence of an explosive mixture of flammable ammonia gas or vapour and air are referred to as 'hazardous', and other areas as 'safe' or 'non-hazardous'. Any electrical equipment used in

[7] Ammonia is defined in BS EN 378-1:2008 as a B2 group refrigerant in Table E.1 — Refrigerant designations.

hazardous areas, including gas detection equipment, must be specially tested and approved to ensure that, in use even under a fault condition such equipment cannot be the cause of an explosion being initiated.

- Electrical apparatus should be selected in accordance with BS EN 60079-14:2014 Electrical apparatus for explosive gas atmospheres Part 14: Electrical installations in hazardous areas (other than mines), and non-electrical equipment should be selected in accordance with BS EN 13463-1:2009 Non-electrical equipment for potentially explosive atmospheres.

<u>Externally-sited plant</u>

14 Compressors and refrigeration plant sited in outdoor locations in otherwise non-hazardous areas will not normally require specially protected electrical equipment except for weather protection.

**Abnormal operating conditions**

15 In the event of a major loss of refrigerant, unprotected electrical equipment, which is outside the hazardous zone but in the same room or adjacent, shall be electrically isolated when the refrigerant concentration reaches 20% of the lower flammable limit or less. Unless the gas detection system provides a pre-alarm before any electrical equipment is isolated the trip level shall be as low as practicable without risk of false alarms.

16 Equipment which remains live when the refrigerant concentration exceeds this trip level, for example ventilation fans and emergency lighting, shall be suitable for operation in a hazardous area. This applies to all electrical equipment and power supplies in the room, and not only to the refrigeration system.

17 Clause 8 of BS EN 378-3:2008 sets outs the requirements for ammonia gas detectors that shall be installed in machinery rooms in order to raise alarms and initiate emergency mechanical ventilation.

18 The gas concentration levels at which this emergency detection equipment shall operate is set out in Paragraph 8 of Appendix 1 of this document.

19 Machinery rooms shall be vented outdoors using mechanical ventilation in case of a release of ammonia refrigerant due to leaks or rupture of components. This ventilation system shall be independent of any other ventilation system on the site.

20 Clause 5.16.4 of BS EN 378-3:2008 provides details for calculating the required airflow for emergency mechanical ventilation located in machinery rooms.

<u>Gas detectors</u>

21 The detectors shall be suitably positioned, taking into account the physical characteristics of the machinery room, the pattern of airflow movement in it and the most likely sources of potential leakage. Due regard should be paid to any dead pockets or recesses. In certain circumstances it is possible for cold ammonia vapour to stratify at low levels.

22 As a rough guide, detectors near to the compressor shaft seals and other non-static items of plant and at ceiling level on a grid at 10 to 20 m intervals, dependent on air flow and location would probably be sufficient, although more may be necessary if there are deep beams creating recesses. The objective is to ensure that the ammonia is detected and the apparatus made safe before flammable concentrations reach a source of ignition.

23 The detectors shall be suitable for a Zone 2 hazardous area.

24 The detectors used may be subject to poisoning by airborne contaminants, including ammonia itself. Some types of ammonia detectors can become exhausted or consumed. It may be necessary to monitor the lifetime of the sensor. Detectors should therefore be properly installed and maintained and periodically checked.

25 The detectors must be capable of detecting concentrations of ammonia at 1% v/v or less.

26 The use of ammonia detectors triggering at low ammonia level, for example 100 ppm, can be considered for use in un-staffed areas, such as ceiling voids containing piping.

**Associated electrical apparatus**

27 Take account of the electrical control system circuitry and achieve the maximum possible degree of failure to safety, so far as is reasonably practicable.

28 The isolating device(s), automatically operated, which cuts off the electricity supply to the ammonia machinery room, shall be located in a non-hazardous area. It can be either a contactor or circuit breaker. Provided the requirements set out above in this Appendix have been satisfied, the following recommendations in paragraphs 28 and 29 below should be adopted.

29 Attention will also need to be paid to the control of other circuits which enter the plant room and are not directly associated with the plant, for example socket outlets for portable tools and in addition any communications, alarm, data and monitoring circuits etc.

**Machinery rooms**

30 Isolation of all electrical circuits should be effected by isolating devices located in a non-hazardous area and controlled by one or more suitable ammonia gas detectors. The gas detectors should also be arranged to give a visual and audible alarm and to switch on equipment for ventilation and/or emergency lighting, if installed. The ventilation air should be discharged to the outside of the building in a way which does not cause distress or danger to people near the building

## APPENDIX 3 – RECOMMENDED SCHEDULE FOR INSPECTION AND MAINTENANCE OF REFRIGERATION SYSTEMS (BASED ON APPENDIX G OF THE INSTITUTE OF REFRIGERATION SAFETY CODE FOR COMPRESSION REFRIGERATION SYSTEMS UTILIING AMMONIA)

### Inspection and maintenance: General

1 A precise inspection and maintenance regime for an individual system is determined by conducting a suitable and sufficient risk assessment. Such an inspection and maintenance regime, and the underpinning risk assessment will need to be periodically reviewed to ensure it reflects the systems current condition and operating parameters

2 This Appendix contains recommendations on the type and frequency of inspections and maintenance required to ensure the safety of refrigeration systems. Paragraphs 5 to 43 below cover the major groups of equipment likely to be incorporated in systems; within these sections are given details of routine inspection (and maintenance where applicable) to be carried out with the system in normal use, then more detailed inspection and maintenance to be undertaken periodically. This information is summarised in Table 1.

3 These recommended intervals quoted in Table 1 based upon information provided by the Institute of Refrigeration are based on proven industry experience. However, under the PSSR the frequency and type of inspection may be varied at the discretion of the 'competent person', based on experience of the particular system. For example, it may be appropriate to inspect plant with active degradation mechanisms, or those systems with a large inventory and an associated high risk, more frequently.

4 A supplier's instruction manual covering the refrigerating system and its components should be available for consultation, together with all records and documentation relevant to the system, including maximum operating pressures for all parts of the system. A schematic refrigeration or flow diagram should be available, clearly identifying controls and valves required for an emergency shutdown.

5 The type and frequency of inspection and maintenance will also depend on the effectiveness of previous maintenance, the age of the system, the environment in which the system is located and the duty of the system. Particular attention should be paid to systems in the period immediately following installation and after any prolonged period of non-operation.

### Compressors

<u>Operational inspection</u>

6 With the system in normal operation, the refrigeration suction and discharge pressures and temperatures, the inter-stage or intermediate pressure and temperature (where applicable) and the oil pressure, should be compared with permissible and normal operating conditions. Oil level should be observed and oil

added (or removed), if required; it is potentially dangerous to have an oil level either above or below the level of sight glass.

7 The compressor and associated piping and equipment should be examined for abnormal vibration. Excessive vibration can cause piping to fail and can also cause failure of the internal moving parts of the compressor, with dangerous consequences.

8 The interval between compressor inspection and maintenance involving opening up of the compressor is usually on the basis of hours run, and the manufacturer's instructions should be consulted. It is usually convenient to time such inspection and maintenance to coincide with routine maintenance such as an annual oil change, during which filters and strainers will need to be withdrawn, cleaned or changed.

9 Before any inspection or overhaul dismantling of a compressor is undertaken, the compressor shall be isolated from the ammonia, evacuated and the compressor motive power securely isolated to prevent the compressor being started.

**Protective devices**

9 All cut-outs and protective devices including HP (High Pressure) cut-outs, oil pressure differential switches and, where fitted, LP (Low Pressure) and IP (Inter-stage Pressure) cut-outs, discharge and oil temperature cut-outs, should be tested at yearly intervals.

10 Bursting discs and some pressure relief valves cannot be satisfactorily tested in place, and recommended replacement intervals are given in paragraphs 31 to 36 below.

**Pressure vessels and heat exchangers**

11 Recommended intervals between inspections are given below, but the interval between inspections may need to be reduced in some circumstances, for example:

- The period of service immediately following commissioning or re-commissioning an installation;
- Corrosive or adverse environmental conditions;
- Information derived from current service conditions on the system or on similar systems;
- Possible effect of loading, including cyclic loading leading to fatigue which may occur if hot gas is injected.

Weekly

12 Weekly, while the system is operational, the appearance of the external surfaces of pressure vessels and heat exchangers, or of the insulation applied to such vessels or heat-exchangers should be visually inspected.

13 Weekly, or at regular intervals indicated by the rate of oil addition, oil should be drained from appropriate oil drain points.

14 Weekly the system should be checked for the presence of non-condensable gases; if necessary these gases should be purged, from receiver(s) and/or condenser(s), preferably into a non-condensable gas remover or purger but alternatively into water. Where an automatic purger is fitted, confirm its correct operation. If there is a large accumulation of non-condensable gases the reason should be investigated and any fault corrected.

Monthly

15 Monthly, coil grid or plate heat exchangers should be inspected for the possible build-up of dirt or other contamination on tubes or fins and cleaned as appropriate: they should also be checked for damage which should be made good as necessary. Defrost elements should be tested electrically for correct operation.

Annual inspection

16 At intervals of not more than 12 months where vessels and heat exchangers are in daily use, a detailed examination of the external surface or of the insulation applied to the external surface of such vessels and heat exchangers should be carried out. This should be conducted by people other than the normal system operators and could be performed by, for example the user's Maintenance Supervisor, Engineering Manager or a specialist contractor.

17 In the case of pressure vessels and heat exchangers covered by insulation, any effects of dampness or deterioration of the insulation which could lead to the eventual corrosion of the vessel or its connections should be investigated and recorded in the log. Surface treatment should be applied to the vessels if required and the insulation should be made good within the shortest practicable time.

18 At least annually, filters and strainers should be cleaned and inspected for damage and replaced if necessary. Tube bundles in heat exchangers, particularly evaporative condensers should be inspected and cleaned if necessary. Any equipment associated with the vessels and heat exchangers, such as agitators, should be examined for damage or deterioration and repaired if necessary. Automatic controls such as head pressure controls should be tested for correct operation and serviced in accordance with the manufacturer's instructions.

**Un-insulated vessels and heat exchangers**

19 Un-insulated vessels and heat exchangers should be given a thorough visual examination, supplemented if appropriate by additional non-destructive techniques.

**Insulated vessels and heat exchangers**

20 Special considerations arise in connection with insulated vessels and heat exchangers in that inspection without removal of insulation is usually impracticable. Experience has shown that insulated vessels operating permanently at temperatures below 0ºC show little evidence of degradation provided the insulation and vapour seal remain sound. Accordingly, for such a vessel the competent person may at his or her discretion waive further inspection of the vessel until the next inspection is due. At any major repair or renewal of the insulation the opportunity must be taken to examine the vessel.

21 Where the temperature of insulated vessels cycles through freezing, or where branches extend to regions above freezing, deterioration is more likely and the degree and frequency of inspection should take this into account.

22 Where insulation is unsound or damaged a visual inspection of the underlying vessel or heat exchanger should be carried out, this should be supplemented if appropriate by additional non-destructive techniques.

**Shut-off valves**

23 A visual inspection of shut-off valves associated with machinery such as compressors and vessels should be included in the operational inspection of such machinery and a record kept. Any fault such as accidental damage or icing which could prevent the operation of a shut-off valve when required should be corrected promptly.

24 Every 6 months, for valves with exposed carbon steel spindles the condition of the spindle and of the gland sealing should be inspected and the spindle cleaned and re-greased. This would not be necessary for stainless steel spindles.

25 Additionally, an external inspection of valves should be carried out; this can conveniently be done as part of the regular inspection of piping. Where a valve spindle is without a hand-wheel and capped, the valve cap should be removed and condition of spindle and gland seal checked as in the preceding paragraph. Bodies and bolts of insulated valves should be inspected as part of the associated piping. Seals should be replaced at intervals as recommended by the valve manufacturer.

26 At least every 4 years (unless the manufacturer does not recommend a shorter period), all shut-off valves should be tested for function. The seating or seals of all shut-off valves essential for the safe operation and maintenance of the system should, if found faulty, be overhauled as necessary to restore full function or be replaced.

**Control valves**

27 Most automatic control valves have no external moving parts requiring maintenance; they should be dismantled and overhauled when recommended by their manufacturers or when found faulty in service or when tested.

28 Annually, valves which are automatically controlled should be tested for correct function; this is often done by changing the setting of the controlling device and observing the response.

**Pressure relief devices**

29 Pressure relief devices are commonly one of two types, bursting discs or spring-loaded valves.

30 Every 6 months, pressure relief devices should be visually inspected for corrosion or accumulation of scale and for leaks. The sealing or locking device that prevents unauthorised tampering should also be inspected. Vent lines should be inspected to ensure that they are clear, that they discharge to a safe place and are protected against ingress of moisture, which could freeze.

31 All bursting discs should be replaced as stated in Table 1 or in accordance with the requirements of a WSE.

32 At least every 5 years' pressure relief valves (or cartridges) shall be removed and replaced with new or with overhauled and recalibrated valves (or cartridges) provided a shorter period is not recommended by the manufacturer of such devices.

33 Before existing pressure relief valves are recalibrated they should first be tested to confirm that they would have operated correctly. Any devices that do not operate within 10% of their setting should be automatically replaced and the periodicity of functional testing reviewed accordingly.

34 All replacement pressure relief devices shall be correctly selected both for set or operating pressure and for capacity or throughput.

**Sensing devices**

35 Maintenance is not usually required except as found necessary during inspection and operational tests, but manufacturer's instructions for inspection, testing and overhaul should be followed.

36 At least annually safety cut-outs should be tested; pressure gauges used in the testing of any safety cut-outs should be calibrated.

**Piping**

37 Where pipework is not included in the WSE but its failure could result in harm, then it should be examined by an Independent Inspector or someone competent to ensure that it is fit for continued use. Regardless of whether the pipework is included in the written scheme, PSSR states that the user is expected to keep the whole system, including pipework, in good repair.

Un-insulated piping

38 Annually, all un-insulated piping and associated components such as flanges and supports should be inspected for any damage to or deterioration of the piping or its protective finish and remedial action taken where necessary.

39 Loss of metal where considered by subjective assessment to be greater than 10% of original wall thickness, should be checked accurately by using techniques such as ultrasonic thickness measurements. If such wall thinning is confirmed it is recommended that expert advice is sought, for example from an engineering insurance inspectorate, to determine the need for and extent and timing of any replacements.

Insulated piping

40 Any mechanical damage to insulation should be repaired immediately and the vapour seal reinstated to prevent access of water or water vapour which will lead to breakdown of insulation and corrosion of the pipework.

41 At least as part of the annual piping inspection, but preferably more frequently, the external condition of the insulation and supports should be inspected. Condensation or frosting on the surface of insulated finishes indicates a deterioration or breakdown of the insulation or vapour barriers. Sections of insulation which are obviously in poor condition should be removed and the integrity of the piping thus exposed determined, with the aid of non-destructive testing techniques as appropriate. Piping should be replaced as necessary, and protective coatings, insulation and vapour seal re-applied.

42 Routine inspection of piping under insulation that is in good condition is not normally required but a programme for inspecting sample areas may be adopted, for example at the discretion of the competent person carrying out the independent full inspection.

## Independent full inspection

43 The frequency at which the vessels, heat exchangers, protective devices and pipework should be independently examined by a competent person should be stated in the WSE.
The competent person should conduct examinations and tests to satisfy him or herself that the equipment is safe for further use. If the examinations indicate that remedial work is required, the competent person shall specify such repairs as he or she may consider necessary. Special attention should be paid to possible deterioration of areas around the supports particularly of horizontal vessels and the attachments to the vessels.

| Item | Major Inspection | Routine Inspection | Schedule including rectifying faults as necessary |
|---|---|---|---|
| System | Annually | Weekly | Check for correct ammonia charge including liquid levels |
| | | Weekly | Check and record operating pressures and temperatures and compare with commissioning logs for significant deviations.<br>If the refrigeration system is manually controlled, it is good practice to ensure logs are completed regularly; ideally daily but at periods that do not exceed 72 hours. |
| | | Monthly | Leak test system. Record ammonia added or removed and disposal |
| | | Monthly | Analyse heat transfer fluids and adjust concentrations |
| | | Quarterly | Inspect and clean oil filters as required |
| | | Quarterly | Examine all main control and isolating valves for full/free travel, check for leakage and repair valve glands as required |
| System | Annually | Weekly | Check for correct ammonia charge including liquid levels |
| | | Weekly | Check and record operating pressures and temperatures and compare with commissioning logs for significant deviations.<br>If the refrigeration system is manually controlled, it is good practice to ensure logs are completed regularly; ideally daily but at periods that do not exceed 72 hours. |
| | | Monthly | Leak test system. Record ammonia added or removed and disposal |
| | | Monthly | Analyse heat transfer fluids and adjust concentrations |
| | | Quarterly | Inspect and clean oil filters as required |
| | | Quarterly | Examine all main control and isolating valves for full/free travel, check for leakage and repair valve glands as required |

| | | | |
|---|---|---|---|
| Pipework | Annually | Weekly | Check for undue vibration, rectify as necessary |
| | | Quarterly | Inspect for damaged insulation /vapour seal, rectify as necessary |
| | | Quarterly | Inspect for evidence of oil at joint locations, rectify as necessary |
| | | Quarterly | Inspect pipework for corrosion, rectify as necessary |
| Pressure vessels and heat exchangers (see note 1) | Annually | Monthly | Check external surface for corrosion/ protective coating damage |
| | | Quarterly | Check insulation and vapour seal for damage |
| | | Quarterly | Check fan sequence, condition and tension of drive belts, unobstructed air |
| | | Quarterly | Check pumps, condition and tension of drive belts |
| | | Quarterly | Check condition and operation of defrost heaters |
| Compressors | Annually | Weekly | Inspect for evidence of oil leakage including shaft seals |
| | | Weekly | Check oil levels. Record oil added or removed and disposal |
| | | Monthly | Check joints and connections for tightness |
| | | Quarterly | Check drive alignment, belt or direct drive in accordance with manufacturer's recommendations |
| | | Quarterly | Ensure drive guards are effective |
| | | Quarterly | Examine drive belts or direct drive couplings for wear and vibration |
| | | Quarterly | Check operation of oil cooler |
| | | Quarterly | Check and ensure correct operation of crankcase heaters, if fitted |
| | | Quarterly | Check condition of anti-vibration mountings & holding down bolts |

| | | | |
|---|---|---|---|
| Compressors (continued) | Annually (continued) | Weekly | Inspect for evidence of oil leakage including shaft seals |
| | | Weekly | Check oil levels. Record oil added or removed and disposal |
| | | Monthly | Check joints and connections for tightness |
| | | Quarterly | Check drive alignment, belt or direct drive in accordance with manufacturer's recommendations |
| | | Quarterly | Ensure drive guards are effective |
| | | Quarterly | Examine drive belts or direct drive couplings for wear and vibration |
| | | Quarterly | Check operation of oil cooler |
| | | Quarterly | Check and ensure correct operation of crankcase heaters, if fitted |
| | | Quarterly | Check condition of anti-vibration mountings & holding down bolts |
| | | Quarterly | Examine for undue noise, vibration or overheating |
| | | Annually | Change oil or as recommended by manufacturer |
| | | Annually | Examine oil filters |
| | | Annually | Sample oil and analyse |
| | | Annually | Check starting sequence |
| | | Annually | Check operation of capacity control system |
| Ammonia liquid pumps | Annually | Quarterly | Examine vent lines for corrosion |
| | | Annually | Defrost, dismantle and examine internal working parts annually or as recommended by manufacturer |
| Safety controls | Annually | Quarterly | Check settings and operation |
| Relief device indicator | Annually | Quarterly | Check function |
| Relief valve outlets | Annually | Quarterly | Check venting clear and to safe place |

| | | | |
|---|---|---|---|
| Electrical control panels | Annually | Annually | Visually check condition, including signs of overheating, of all components. Repair or replace as necessary. All items of electrical equipment (and their associated circuits) which have explosion protection characteristics, e.g. Ex'd', Ex'e' etc. shall be subjected to the inspection requirements of BS EN 60079-17 including the production of inspection schedule check-lists. |
| | | Quarterly | Check tightness of all terminals taking care not to damage threads |
| Electrical components | Annually | Annually | All items of electrical equipment (and their associated circuits) which have explosion protection characteristics e.g. Ex'd', Ex'e' etc. shall be subjected to the inspection requirements of BS EN 60079-17 including the production of inspection schedule check-lists. Check integrity to seals of components |
| High /Side Bursting discs | Every 5 years unless a shorter interval is specified by the manufacturer (see note 2) | | Replace as stated |
| Low / Side Bursting discs | Every 5 years (see note 2) | | Replace as stated |
| Relief valves venting to atmosphere | Every 5 years (see note 2) | Annually | Visual inspection of device and vent line to safe location |
| | | Every 5 years | Replace, or overhaul and recalibrate as stated in PSS Regulations Written Scheme of Examination |
| Relief valves venting to low side | Every 5 years (see note 1) | Annually | Annual visual examination where reasonably practicable |
| | | Every 5 years | Pressure setting tested every five years |

Note 1: Plate heat exchangers should be inspected and maintained strictly in accordance with the manufacturer's published recommendations.

Note 2: The frequency of inspection for all safety devices should not exceed the period specified by the manufacturer.

Before existing pressure relief valves are recalibrated they should first be tested to confirm that they would have operated correctly. Any devices that do not operate within

10% of their setting should be automatically replaced and the periodicity of functional testing reviewed accordingly.

**Table 3.1 - Major Inspection by Senior Maintenance Staff/Specialist Contractor and Routine inspection by on site operating/staff/Specialist contractor.**

The above Table 3.1 is based upon the recommendations set out in the Guidance Note on the Maintenance of Refrigerating Systems containing Refrigerant R717 Ammonia published by the Institute for Refrigeration.

## APPENDIX 4 – STATEMENT FROM HSE CONCERNING THE INTERPRETATION OF THE TERM 'USER' IN THE PRESSURE SYSTEMS SAFETY REGULATIONS 2000

1 The 'user' is defined in the Regulations as the 'employer or self-employed person' who has control of the operation of the pressure system.

2 For certain pressure systems, such as refrigeration plant, where more than one employer or self-employed person has an interest in the running of the system, the question of who is the 'user' can only be answered by looking at the facts.

3 Once it has been decided on the facts which employer or self-employed person is the 'user', then that person is responsible for complying with the Regulations. In particular, that person must arrange for action to be taken to comply with:

- Regulation 7, establishment of safe operating limits for the plant;
- Regulations 8 and 9, which require a suitable written scheme of examination for the system, and that the examinations are carried out properly;
- Regulation 11, provision of adequate and suitable instructions for the system;
- Regulation 12, maintain the system in good repair.

4 In taking action to comply, the 'user' may use his or her own resources, or ask another organisation to carry out some work. If another organisation is used, the 'user' still retains the duty to comply with the Regulations.

5 To decide who is the 'user', certain factors need to be looked at to determine where 'control of the operation of the pressure system' lies. Using the example of refrigeration plant, the factors include:

- Who decides when the refrigeration plant will be turned off or on..?
- Who decides who has access to the refrigeration plant..?
- Who is responsible for the controls on the plant..?
- Who maintains and runs the plant on a day-to-day basis..?

6 In looking at these factors, some will have more weight than others. For example, an employer who owns refrigeration plant may pay a contractor to switch the plant on and off (amongst other things), but retain authority to decide *when* the plant will be turned on or off. In this situation, the contractor would not be considered by HSE to have 'control of the operation of the system', and consequently the duties of the 'user' rest with the employer who owns the plant.

7 Continuing the example in paragraph 6, it is *possible* for two employers (or self-employed persons) to devise a way in which the pressure system is controlled so that it is *clearly* the contractor who has full control of the operation of the refrigeration plant. In such circumstances, the duties of the 'user' would be for the second party (the contractor) to fulfil.

8 Where refrigeration contractors (RCs) have been contracted to carry out examination under WSEs for client companies, the following points should be noted:

- The client should take reasonable steps to ensure that the RC maintenance contractor is also a competent person within the meaning of PSSR; and
- The RCs should be aware that accepting the work of examining under a WSE means taking on all the responsibilities of a competent person, and they will have to fulfil the criteria for a competent person to accept the work.

9 The above statement has been prepared to clarify HSE's interpretation of the word 'user' and it should be remembered that an authoritative interpretation of the law can only be provided by the Courts.

## APPENDIX 5 - EMERGENCY PROCEDURES AND TOXIC LEVELS OF CONCERN

### Emergency Procedures

1. All workplaces need a plan for emergencies that can have a wider impact. Special procedures are needed for emergencies such as ammonia spills and releases.

2. In emergencies people are more likely to respond reliably if they;

   * are well trained and competent;
   * take part in regular and realistic practice drills; and,
   * have clearly agreed, recorded and rehearsed plans, actions and responsibilities.

3. Employers shall write an emergency plan if a major incident at their workplace could involve risks to the public, rescuing employees or co-ordinating emergency services. In addition, where the workplace is shared with another employer you should consider whether your emergency plans and procedures should be co-ordinated.

4. See http://www.hse.gov.uk/toolbox/managing/emergency.htm for further guidance regarding emergency procedures.

5. Ammonia is an irritant gas that produces effects immediately on contact with moist mucous membranes of the eyes, mouth, and respiratory tract via the formation of ammonium hydroxide (a corrosive alkali) or the production of heat. Because of its irritant properties, individuals coming into contact with ammonia vapour (or gas) will try to escape as quickly as possible. The odour threshold for ammonia is lower than its irritancy effect and serves as a warning of its presence. See also paragraphs 3 to 8 of the main guidance.

6. Mathematical and computer models are available that have been designed especially for use by people responding to chemical releases, as well as for emergency planning and training, and helping to assess the extent of the threat of the dispersal under a range of prevailing weather conditions. Such models can also be used to obtain predicted indoor and outdoor concentrations at any location of special concern. It is recommended that where appropriate specialist advice should be sought in their use.

7. Dispersion is a term used by modellers to describe the moving and spreading of a vapour cloud. A dispersing ammonia vapour cloud will generally move (advect) in a downwind direction and spread (diffuse) in a crosswind and vertical direction. Although ammonia is lighter than air it will, in the presence of moisture (such as high relative humidity), form vapours that are heavier than air. A cloud of gas that is denser or heavier than air (called a heavy gas) can also spread upwind to a small extent.

8. When you are modelling an ammonia release you should assess the toxicity threat, for one or more toxic Levels of Concern (LOCs).

**Toxic 'Levels of Concern' (LOC)**

9. A toxic LOC means the level (threshold concentration) of exposure to an airborne chemical that could hurt people if they breathe it in for a defined length of time (exposure duration).

10. The purpose of the ACUTEX[8] project was to set up a methodology for acute exposure levels, known as Acute Exposure Threshold Levels (AETLs) in Europe. The methodology for setting AETLs was published in 2006. Draft AETLs were developed for about 20 chemicals as part of ACUTEX, but these were never subject to peer review or finalised and the technical supporting documents are not publicly available. There has been no further progress since the ACUTEX project finished in 2006 and it is probable that this initiative is permanently stalled.

11. Originally it was intended that AETLs would be used within Member States, where appropriate, to inform decisions on land-use planning and emergency planning. It was also intended that AETLs would be complementary to US Acute Emergency Guideline Levels (AEGLs)[9] while meeting needs specific to European users.

12. AEGLs are guideline levels for once-in-a-lifetime short-term exposures to airborne concentrations of acutely toxic substances. It is anticipated that they will be used in emergency planning and prevention as well as during real-time emergency response actions. This is in relation to the manufacture, processing, storage and transportation of chemicals and cleaning-up pollution. The context is both accidental and terrorist releases of chemical substances.

13. It should be noted that these public exposure guidelines are not the same as workplace exposure limits (such as TWA) that were designed to protect workers and not for use in assessing the hazard to people exposed to toxic gas during an accidental release.

14. AEGLs estimate the concentrations at which most people—including sensitive individuals such as old, sick, or very young people—will begin to experience health effects if they are exposed to a hazardous chemical for a specific length of time (duration). For a given exposure duration, a chemical may have up to three AEGL values, each of which corresponds to a specific tier of health effects. The three AEGL tier levels are defined as follows:

[8] The aim of the Acute Exposure project, ACUTEX, was to develop a methodology for establishing European Acute Exposure Threshold Levels (AETLs) for toxic substances in relation to harm to people by inhalation.
[9] The Development of Acute Exposure Guideline Levels (AEGLs) is a collaborative effort of the public and private sectors worldwide. AEGLs are intended to describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals. The US National Advisory Committee for the Development of Acute Exposure Guideline Levels for Hazardous Substances (AEGL Committee) is involved in developing these guidelines to help both national and local authorities, as well as private companies, deal with emergencies involving spills, or other catastrophic exposures.

* **AEGL-1** is the airborne concentration (expressed as ppm [parts per million] or $mg/m^3$ [milligrams per cubic meter]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure.
* **AEGL-2** is the airborne concentration (expressed as ppm or $mg/m^3$) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape.
* **AEGL-3** is the airborne concentration (expressed as ppm or $mg/m^3$) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

| **Acute Exposure Guidelines for Ammonia** | | | |
|---|---|---|---|
| **Exposure time** | **AEGL-1 (ppm)** | **AEGL-2 (ppm)** | **AEGL-3 (ppm)** |
| 10 minutes | 30 | 220 | 2,700 |
| 30 minutes | 30 | 220 | 1,600 |
| 60 minutes | 30 | 160 | 1,100 |
| 4 hours | 30 | 110 | 550 |
| 8 hours | 30 | 110 | 390 |

**Table 5.1 - Final AEGLs for ammonia (in parts per million)**

15. Typically, the AEGL values will be different for each different ‘exposure duration’ (such as the AEGL-3 values in Table 5.1 above). This is because the physical effects are typically related to dose (that is, concentration over exposure duration). However, in some cases, the AEGL values will be the same for all durations. This situation usually occurs at the AEGL-1 level (as in Table 5.1 above), because it is a threshold for non-disabling effects; some effects (for example, whether people will be able to smell the chemical) depend only on concentration—not on the length of time people are exposed.

16. Besides AEGLs other toxic LOCs exist. These include Emergency Response Planning Guidelines (ERPGs), Temporary Emergency Exposure Limits (TEELs) and Protective Action Criteria for Chemicals (PACs).

17. ERPGs and TEELs are normally used if AEGLs are not available and the PACs dataset is a hierarchy-based system of the three common public exposure guideline systems: AEGLs, ERPGs, and TEELs.

**Immediate Dangerous to Life or Health (IDLH) concept**

18. IDLH refers to a concentration, formally specified by a regulatory value, and defined as the maximum exposure concentration for a given chemical in the workplace from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects. The IDLH for ammonia is 300ppm.

**COMAH On-site Emergency Planning and Mitigation**

19. In the rare event an ammonia refrigeration system holds 50 tonnes or above the Control of Major Accident Hazards Regulations 2015 (COMAH) apply. For further details, refer to ACoP L111 - A guide to the Control of Major Accident Hazards Regulations 2015.

## APPENDIX 6 – FURTHER GUIDANCE

This guidance note is set out against a background of legislation in force in the United Kingdom at the time of publication. However, it should be noted that the following list is not exhaustive.

All relevant legislation must be complied with and Approved Codes of Practice (ACOPs), official Guidance Notes, and referenced codes, standards, etc. shall be taken into account.

Where British Standards, etc. are quoted, equivalent national or international standards, etc. may be equally applicable.

Care shall be taken to ensure that the latest editions of the relevant documents are used.

### Legislation

Health and Safety at Work etc. Act 1974

Management of Health and Safety at Work Regulations 1999

Construction (Design and Management) Regulations 2015

Pressure Systems (Safety) Regulations 2000

Dangerous Substances and Explosive Atmospheres Regulations 2002

Control of Substances Hazardous to Health Regulations 2002

Electricity at Work Regulations 1989

The Health and Safety (Safety Signs and Signals) Regulations 1996 (the Safety

Signs Regulations)

Regulatory Reform (Fire Safety) Order 2005

Control of Major Accident Hazards Regulations 2015

Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009

### HSE Guidance and Other Documents

HSG85 Electricity at Work

L111 A guide to the Control of Major Accident Hazards Regulations 2015. ACoP

L122 Pressure Systems Safety Regulations 2000. ACoP

L138 Dangerous substances and explosive atmospheres. ACoP

Further information is available from the HSE via their website: http://www.hse.gov.uk/fireandexplosion/dsear.htm

INDG73 Working alone – Health and safety guidance on the risks of lone working.

**British European Standards**

| | |
|---|---|
| BS EN 378-1:2008 +A2:2012 | Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1: Basic requirements, definitions, classification and selection criteria |
| BS EN 378-2:2008 +A2:2012 | Refrigerating systems and heat pumps — Safety and environmental requirements — Part 2: Design, construction, testing, marking and documentation |
| BS EN 378-3:2008 +A1:2012 | Refrigerating systems and heat pumps — Safety and environmental requirements — Part 3: Installation site and personal protection |
| BS EN 378-4:2008 +A!:2012 | Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery |
| BS EN 1984:2010 | Industrial valves. Steel gate valves |
| BS EN 60079-0:2012+A11:2013: | Classification of areas for explosive gas atmospheres - Explosive atmospheres. Equipment. General requirements |
| BS EN 60079-10-1:2009 | Explosive atmospheres. Part 10-1. Classification of areas. Explosive gas atmospheres (Second edition) |
| BS EN 60079-14:2014 | Explosive atmospheres. Electrical installations inspection and maintenance |
| BS EN 60079-17:2014 | Explosive atmospheres. Electrical installations, design, selection and erection in potentially explosive gas atmospheres |
| BS EN 60079-20:2010 | Explosive atmospheres. Material characteristics for gas and vapour classification. Test methods and data |
| BS EN 62305:2011 | Protection against lightning |
| BS EN 13463-1:2009 | Non-electrical equipment for potentially explosive atmospheres. Basic method and requirements |
| BS EN 13313:2010 | Refrigerating systems and heat pumps. Competence of personnel |

British Standards can be purchased from the British Standards Institute via their website: http://shop.bsigroup.com/

**Other guidance:**

EEMUA Publication 231 – Ed 1, SAFed Publication IMG 1 The mechanical integrity of plant containing hazardous substances. A guide to periodic examination and testing. Published by the Safety Assessment Federation (SAFed) and the Engineering Equipment & Materials Users' Association (EEMUA) in consultation with the Health and Safety Executive's Hazardous Installations Directorate in September 2012.

Safety Assessment Federation, Unit 4, First Floor, 70 South Lambeth Road, Vauxhall London, SW8 1RL. www.safed.co.uk

Engineering Equipment & Materials Users' Association, 63 Mark Lane, London, EC3R 7NQ. www.eemua.org

Safety code of practice for refrigerating systems utilising refrigerant R717 (Ammonia). Published by the Institute of Refrigeration, Kelvin House, 76 Mill Lane, Carshalton, Surrey SM5 2JR

Guidance Note on the Maintenance of Refrigerating Systems containing Refrigerant R717 Ammonia. Published by the Institute of Refrigeration.

Revised International Institute of Ammonia Refrigeration Bulletin R1. Available from the Institute of Refrigeration.