Bulletin No. 112 6/98

Guidelines for:

Ammonia Machinery Room Design

International Institute of Ammonia Refrigeration

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Table of Contents

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1.0 INTRODUCTION

The refrigeration machinery room contains much of the fixed equipment for a refrigerated facility. Proper machinery room design will afford a safe and efficient ammonia refrigeration system. While the mechanical code and other codes and standards provide minimum safety requirements for machinery rooms, there are other recommended practices generally accepted in the industry.

2.0 SCOPE

This guideline summarizes generally accepted industry practice for ammonia machinery rooms and references relevant codes and standards where instructive. The recommendations in this guideline are most applicable to completely new ammonia machinery rooms. Application to the evaluation and/or renovation of existing machinery rooms may be impractical for a variety of reasons and should be done only with careful consideration.

3.0 REFERENCE SOURCES

The information in this bulletin is intended to summarize generally accepted industry practices. The bulletin does not provide a comprehensive treatment of existing code and standard requirements, as these vary from place to place. It is not intended to impose new requirements beyond those in existing codes and standards. It should be noted that certain jurisdictions have specific code requirements that are more stringent than the practices described herein.

Reference documents used in the development of this bulletin include:

- ANSI/ASHRAE 15-1994, *Safety Code for Mechanical Refrigeration*
- ANSI/IIAR 2-1992, *Equipment, Design, and Installation of Ammonia Mechanical Refrigeration Systems*
- IIAR Bulletin 109, *Minimum Safety Criteria for a Safe Ammonia Refrigeration System*
- IIAR Bulletin 110, *Startup, Inspection, and Maintenance of Ammonia Mechanical Refrigeration Systems*
- IIAR Bulletin 111, *Ammonia Machinery Room Ventilation*
- ANSI/NFPA 68, *Guide to Venting of Deflagrations*
- ANSI/NFPA 70, *National Electric Code*
- *International Mechanical Code 1997*
- ANSI/NFPA 1-1997, *Fire Prevention Code*
- *Standard Mechanical Code 1994, Standard Building Code 1994, Standard Fire Code 1994*
- *National Mechanical Code 1993, National Building Code 1996, National Fire Code 1996*
- *Uniform Mechanical Code 1997, Uniform Building Code 1997, Uniform Fire Code 1997*
- IIAR *Ammonia Data Book*

4.0 DESIGN REQUIREMENTS AND CONSIDERATIONS

4.1 General

Design requirements and considerations are categorized into the main engineering disciplines. Note that machinery room ventilation is specifically addressed by IIAR Bulletin 111 (10/91) so this bulletin does not provide the same level of detail. The terms "must" and "shall" are used to indicate that an item is a requirement in some code or standard. Where possible, a reference to the relevant code or standard is given in italics, but these are not all-inclusive, particularly where the requirement exists in several codes and standards. Any requirement referenced applies only to systems in jurisdictions where the referenced code or standard has been adopted by law. The term "should" indicates that an item is discretionary but normally recommended.

4.2 Site Considerations

Site considerations would be applicable to situations where a totally new refrigerated facility is to be constructed. Other than for any specific state or local building codes or zoning ordinances, the following site considerations are discretionary as opposed to being code requirements.

(a.) **Proximity to Surface Waters.** Topography of the site should prevent any possibility of an ammonia spill reaching surface waters such as creeks, streams, rivers, lakes, or ponds per all state and federal regulations. Federal regulation includes section 311(b)(2)(A) of the Federal Water Pollution Control Act and 40 CFR Part 116 Section 4, Designation of Hazardous Substance and 40 CFR Part 117 Section 3, Reportable Quantities of Hazardous Substances Designated Pursuant to Section 311 of the Clean Water Act. State regulations may also apply to on-site ponds used for decorative or fire protection purposes. Check with your local authority. A site drainage plan shall be prepared per the USEPA National Pollutant Discharge Elimination System, 40 CFR Part 122, Section 26, Storm Water Discharges, and any applicable State NPDES program.

(b.) **Proximity to Off-Site and Major Traffic Thoroughfares.** Machinery rooms should be located on the site with due consideration for proximity to off-site major traffic thoroughfares as well as to nearby neighbors and prevailing winds. Machinery room location considerations should include safety, noise hazards and off-site effects. U.S. Environmental Protection Agency Risk Management Program regulations require that facilities with greater than 10,000 lb ammonia consider off-site public receptors. (See IIAR *Process Safety Management and Risk Management Program Guidelines for Ammonia Refrigeration* for more detail.) Refer to local and state codes for requirements on this topic.

(c.) **Arrangement of Machinery Room to Overall Facility**. The machinery room location relative to the rest of the refrigerated facility is important. Following are lists of preferred locations.

Preferred Locations:

- Ground level
- Separate building (or sharing a building with another utility system)
- Peninsular part of main building with three exposed walls and exposed roof

remote from heavily occupied areas

- Along exterior of main building having one or two exposed walls and exposed roof remote from heavily occupied areas

Least Desirable:

- Inner areas of building with no exterior wall exposure
- Adjacent to (horizontally or vertically) heavily occupied areas such as office and employee welfare facilities
- Basement of building
- Building floors above ground level

(d.) **Access for Emergency Response Vehicles.** Emergency access (i.e., fire lanes) shall be in accordance with all state and local codes, and if practicable, special consideration should be given to direct machinery room access.

4.2.1 Machinery Room Content, Layout and Construction Features

Machinery Room Content, Layout and Construction shall conform to ANSI/IIAR 2-1992, *Equipment, Design and Installation of Ammonia Mechanical Refrigeration Systems*, Section 4, Machinery Room Design with special consideration to the following:

(a.) **Machinery Room Contents.** Preferably the ammonia refrigeration machinery room houses only ammonia refrigeration equipment and direct ancillary equipment such as condenser water pumps. The following equipment shall not be located within a ammonia refrigeration machinery room:

- Boilers and other open flame producing equipment, including open flame space heaters, must not be located in the machinery room.
- Equipment with surface temperatures in excess of 800°F shall not be located in the room without special precautions. (For example, some cogeneration facilities obtain “alternate methods and materials” code variances in order to place turbines and steam boilers in refrigeration areas. Such approvals are considered by code officials on a case-by-case basis and usually require demonstration of equivalent safety to the code requirements.)
- Lubricants or other combustible materials shall not be stored in the machinery room.

(b.) **Machinery Room Layout.** Sufficient space shall be provided to allow access to equipment for maintenance purposes. Adequate clearance for personnel is recommended between equipment.

A minimum of two (2) exits must be provided from the machinery room, and all exits shall be in compliance with all federal, state and local codes and regulations. Exit doors shall swing outward, be equipped with panic-type hardware, and shall not be locked while machinery room is occupied. Doors shall be tight-fitting, and self-closing. An unobstructed path to exit is to be clearly marked.

(c.) **Building Structural Capabilities.** Machinery room structural systems should include provision for concentrated loading from piping, vessels, and equipment. Elevated structural systems should be specifically designed for the actual loads of main headers and hanging vessels, in addition to live loads (snow/water) on the roofing system.

Floor systems should be designed to accommodate the specific static and/or vibrational loads imposed by equipment and vessels, and equipment for servicing (fork truck, portable crane, etc.). Concrete pads may be necessary for major pieces of reciprocating equipment per manufacturer's recommendations.

(d.) **Explosion Venting.** Explosion venting may be required by the facility's insurance company. Factory Mutual System Loss Prevention Data Sheet 7-13 defines a vent area and internal release pressure for these systems and references ANSI/NFPA 68, *Guide to Venting of Deflagrations*, for further information. ANSI/NFPA 68 calculates a conservatively large vent area, which may be difficult to accommodate if the equipment room does not have any outside walls. If the new equipment room is designed for explosion venting with adequate outside wall area, the construction cost increment over designs without explosion venting is generally not large, although special blow-out panels may be necessary.

Explosion-venting design is intended to reduce the possibility of damage from an ammonia deflagration (propagation of a combustion zone at a speed slower than the speed of sound in the unburned mixture). Certain insurance companies have promoted explosion venting design to reduce their risk in insuring an ammonia mechanical room. The deflagration risk of ammonia is normally addressed by ventilation requirements rather than by installing explosion vents. ANSI/ASHRAE 15-1994, ANSI/IIAR 2-1992, and the mechanical and fire codes require ventilation that reduces the probability of ammonia accumulating to explosive levels.

(e.) **Wall Construction.** Walls, floor, and ceiling separating the refrigerating machinery room from other occupied spaces shall be of at least 1 hour fire-resistive construction. *[ANSI/ASHRAE 15-1994, 8.14c]*

(f.) **Floors.** Machinery room floors should be slip-resistant and should be sloped to floor drains. All floor drains shall comply with state or local codes and regulation pertaining to chemicals releases into the environment. Slopes and drain locations should be coordinated with equipment layouts.

(g.) **Access Platforms.** Elevated equipment and branch hand valves located more than seven feet above floor level should be provided with OSHA-approved access platforms and/or ladders, chain operators accessible from the floor, or manually-controlled solenoid valves controlled by a stop switch accessible just outside of the machine room.

4.3 Mechanical

A major part of the mechanical design associated with the construction of an ammonia machinery room is the ventilation system. This subject is addressed in detail in IIAR Bulletin 111, *Ammonia Machinery Room Ventilation*. Bulletin 112 does not attempt to address the design issues of the ammonia refrigeration system itself.

(a.) **Ventilation.** ASHRAE-15, Safety Code for Mechanical Refrigeration Systems, and IIAR-2 are typically the most stringent codes for ventilation requirements. In IIAR Bulletin 111, ventilation volumes are recommended which generally exceed the requirements in the above two codes: intermittent emergency ventilation equal to 10 ft^3/min per ft^2 and a minimum of 20,000 ft^3/min, triggered by an automatic ammonia detector. Additionally, a continuous ventilation rate of 1-2 ft^3/min per ft^2 is recommended.

(b.) **Emergency Eyewash and Shower Facilities.** Because of the potential for eye and skin exposure to ammonia, accessible eyewash and body shower facilities shall be provided. Because of the importance of quick flushing of the eyes in the event of a spray or splash of liquid ammonia, eyewash facilities should be located in the area of the machinery room.

(c.) **Fire Protection Systems.** Insurance underwriters and local building and fire codes typically address the requirements for basic fire protection. Special considerations should be given to providing sprinklers over any major ammonia vessels to keep them cool in the event of a fire.

(d.) **Drainage Systems.** In the event of a spill in the machinery room, liquid ammonia can enter the waste system. High concentrations of ammonia can cause disruption of waste treatment plants, particularly in smaller treatment plants.

(e.) **Critical Ammonia Valves.** Critical hand valves which control the flow of all liquid ammonia and all hot gas to the plant must be located so as to be readily accessible from floor level or access platforms. A "master" solenoid valve controlled by a manual stop button from the floor located by the main machinery room door may be used. Permanent valve tags with reflective trim are recommended. A drawing showing the location of critical valves should be posted outside the machinery room.

(f.) **Identification and Signage.** All ammonia vessels, equipment and piping should be labeled. Identification of piping should include in-house, process color coded descriptive labels, and flow direction arrows. The in-house color coding system should have an index, posted in color in two locations outside the machinery room area.

ANSI/ASHRAE 15-1994 and ANSI/IIAR 2-1992 require signage which is to include:

- Name and address of installing contractor
- Kind and quantity of refrigerant in system
- Field test pressures applied
- Instructions for emergency shutdown
- Name, addresses, and phone numbers for service
- Name, address, and phone number of municipal inspection department

(g.) **Emergency Refrigerant Control Box.** ANSI/IIAR 2-1992 describes (in an informational Appendix) an "Emergency Refrigerant Control Box" to be installed outside the machinery room. This installation, formerly required by several mechanical and fire codes, is intended to provide a firefighter with the means to manually vent the contents

of the refrigeration pressure vessels either to other parts of the system, to atmosphere, or to a water absorption system. Although model fire and mechanical codes have dropped this requirement, it may still be required in some jurisdictions. When an emergency refrigerant control box is required by local (usually fire) code for the manual emergency discharge of ammonia refrigerant, refer to the design guidelines provided by ANSI/ASHRAE 15-1994 Appendix B and ANSI/IIAR 2-1992 Appendix A.

4.4 Electrical

(a.) **Electrical Classification.** So long as the ventilation requirements of ANSI/ASHRAE-15 and ANSI/IIAR-2 (See IIAR Bulletin 111) are satisfied, the machinery room is classified as a "Non-Hazardous Location" by the National Electric Code (NEC). If such ventilation is not provided, all electrical equipment must comply with the requirements for a Class I Division 2 location (which would require specialized electrical gear).

(b.) **Minimize Electrical Equipment.** No electrical equipment should be powered or controlled from the machinery room unless it is directly associated with the refrigeration system.

(c.) **Emergency Remote Control.** While an "emergency refrigerant control box" is no longer required in modern codes, an emergency *refrigeration system* control box is still recommended. This installation, required in some jurisdictions, provides the emergency responder with the controls to (a) perform a safe emergency shutdown of the refrigeration system (or that part which is not Class I Division 2 Group D electrical classification) and (b) start the emergency ventilation system in the refrigeration machinery room.

All emergency remote electrical controls shall be in full compliance with state or local codes and regulations. The following design is recommended as a minimum:

- Remote shut down of nonhazardous-duty machinery room electrical equipment. Proper sequencing of the shutdown can be important.
- Remote activation of exhaust fans.

The emergency switch or switches should be located just outside of the principal exterior exit. The emergency switch should be of the "break-glass" type or in a glass-front control box and should be well identified.

(d.) **Ventilation Equipment Power and Control.** All emergency ventilation system equipment should be powered from a source remote from the machinery room, preferably from an emergency power circuit. Consideration should be given to the electrical classification of the emergency ventilation system; some codes require Class I Group D Division 1 electrical equipment.

(e.) **Lighting.** Machinery room lighting shall be designed to provide a minimum of 30 ft-candle at normal working height. Emergency lighting and exit lighting should be powered from a source external to the room, preferably from an emergency power circuit and should be of waterproof construction. Lighting should also be provided for equipment located outdoors adjacent to the machinery room.

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