American National Standard For

ANSI/IIAR 2-2008, (With Addendum B)

Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems

Approved by the American National Standards Institute June 3, 2008

Supersedes ANSI/IIAR 2-1999 and IIAR2-2008, Addendum A

Addendum B Approved by the American National Standards Institute, December 3, 2012

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International Institute of Ammonia Refrigeration

Notes on the Standard Text

Metric Policy

The IIAR metric policy for ANSI standards, bulletins and all IIAR publications is to use the common engineering "inch-pound" (IP) unit system as the primary unit of measure, and the International System of Units (SI), as defined in United States National Institute of Standards and Technology Special Publication 330 "The International System of Units," for secondary units.

Informative/Normative Elements

This standard includes both Normative (required) and Informative (advisory) language. The body of the standard and labeled appendices are Normative. The foreword, notes, and any appendices labeled Informative are non-mandatory. Informative material shall never be regarded as a requirement.

Notice

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The Standard is subject to periodic review. It may be changed, revised or withdrawn without notice and is only current as of its publication date. Up-to-date information may be received by calling or writing IIAR.

Note that the various codes and regulations referenced in the Standard may be amended from time to time and it should not be assumed that the versions referenced in the Standard are the most current versions of such codes and regulations. Please consult the appropriate regulatory authorities for the most up-to-date versions.

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Foreword (Informative)

This document is intended to serve as a standard for equipment, design and installation of closed-circuit ammonia refrigerating systems. Additional requirements may be necessary because of particular circumstances, project specifications or other jurisdictional considerations. Note that this standard does not constitute a comprehensive detailed technical design manual and should not be used as such.

Experience shows that ammonia is very difficult to ignite and is very stable under normal conditions. The ammonia concentration must be about 1000 times above that considered hazardous to humans before flammability becomes a concern.

Ammonia's strong odor alerts those nearby to its presence at levels well below those that present a hazard. This "self-alarming" odor is so strong that a person is unlikely to voluntarily remain in an area where ammonia concentrations are hazardous.

The principal hazard to persons is ammonia vapor, since exposure occurs more readily by inhalation than by other routes. As with any hazardous vapor, adequate ventilation is the key to effective control.

Ammonia in vapor form is lighter than air. It rises and diffuses simultaneously when released into the atmosphere. It is biodegradable, and when released it combines readily with water and/or carbon dioxide to form relatively harmless compounds. Ammonia may also neutralize acidic pollutants in the atmosphere. Additional information regarding the properties of ammonia is published in the IIAR Ammonia Data Book.

This standard was first issued in March of 1974 by the International Institute of Ammonia Refrigeration (IIAR) as IIAR 74-2. The standard was intended to be a reference document covering the minimum requirements for specific aspects of industrial closed-circuit ammonia refrigerating systems to supplement existing refrigeration standards issued by other organizations such as ASHRAE, ASME and ANSI. The standard was first approved as an American National Standard by the American National Standards Institute (ANSI) in March 1978 as ANSI/IIAR 74−2−1978. A revision of the standard, ANSI/IIAR 2−1984 was approved by ANSI in July 1985, as were subsequent revisions in December 1992, August 1999, June 2008, and August 2010. The most recent revision, ANSI/IIAR 2-2008, Addendum B, received approval from ANSI on December 3, 2012.

This standard was prepared using the Canvass Method whereby organizations and individuals recognized as having interest in the subject of the standard were contacted prior to the approval of this revision. Consensus was achieved by use of the Canvass Method. It was prepared and approved for submittal to ANSI by the IIAR Standards Review Committee and the IIAR Board of Directors.

ANSI/IIAR 2-2008: Changes for the new edition (Informative)

IIAR 2 has undergone an extensive revision to the 1999 version. Some changes are highlighted here to assist users of this document. Largely the content of the standard has not changed, but it has been reorganized and the sections have been renumbered. The Equipment section has been expanded, and each type of equipment now has its own section. The Installation section content has been split between the Machinery Room Design, System Design, and Testing and Charging sections.

- New sections added requiring users to take into account heat loads from cleaning operations for Shell and Tube Evaporators and Plate Heat Exchangers.
- New compressor equipment identification requirement: minimum rotation speed for proper lubrication.
- New requirements for the manufacture of pressure vessel heads added, including hot forming or stress relieving and minimum corrosion allowance.
- Minimum Pipe Wall Thicknesses modified.
- Refrigerant Valves section heavily modified.
- Sections added on Pipe Hangers and Supports, Pipe Marking.
- Section added on Equipment and Piping Hydrostatic Overpressure Protection.
- All headings “Safety” have been changed to “Design” because IIAR 2 is not a safety standard.
- Type A and B specified for A106 pipe.
- Pressure relief requirements of large vessels modified.
- New informative Appendix C *Ammonia Characteristics and Properties*.
- New informative Appendix D *Duplicate Nameplates on Pressure Vessels*.
- New informative Appendix F *Pipe Hanger Spacing, Hanger Rod Sizing, and Loading*.
- New informative Appendix G *Hydrostatic Pressure Relief*.
- New informative Appendix J *Stress Corrosion Cracking*.
- New informative Appendix K *Emergency Pressure Control Systems*.

The changes in Addendum A include:
- Foreword: updated membership list of the Standards Review Committee
- Table of Contents: addition of Appendix “L”
- Section 3: definition of Machinery Room
- Section 4.17: addition of new normative standard
- Section 11.3.3: update of relief piping materials
- Section 13: Entire update of Machinery Room Design section
- Appendix L: New Appendix; “Machinery Room Signage”

The changes in Addendum B include:
- Foreword: updated membership list of the Standards Committee
- Section 10: valve and flange installation

At the time of publication of this revision of the standard, the IIAR Standards Review Committee had the following members:

Robert J. Czarnecki, Chair – Campbell Soup Company
Don Faust, Vice Chair – Gartner Refrigeration & Mfg., Inc.
Eric Brown – ALTA Refrigeration, Inc.
Dennis R. Carroll – Johnson Controls
Jim Caylor – Jacobs Engineering
Wayne D. Davis – M & M Refrigeration, Inc.
Eric Johnston – ConAgra
Gregory P. Klidonas – GEA Refrigeration North America, Inc.
Thomas A. Leighty – Refrigeration Systems Company
Brian Marriott – Johnson Controls
Rich Merrill – Retired, EVAPCO, Inc.
Ron Worley – Nestlé USA
Joe Pillis – Johnson Controls
Peter Jordan – MBD Risk Management

Table of Contents

Section 1

Purpose

The purpose of this standard is to provide minimum requirements for equipment, design and installation of closed-circuit ammonia refrigerating systems.

Section 2

Scope

This standard shall apply only to closed-circuit refrigerating systems utilizing ammonia as the refrigerant.

2.1 This standard was written as a guide to the design, manufacture and installation of closed-circuit ammonia refrigerating systems in industrial occupancies and is not intended to supplant existing safety codes.

In cases where the jurisdictional authority has specific code requirements that are more stringent than those herein, that authority shall prevail.

2.2 This standard applies:

a. To equipment and systems designed, manufactured and installed subsequent to adoption of this standard;

b. To parts or components installed after adoption of this standard.

EXCEPTION:
replacements in kind that meet the design intent for the original application.

2.3 This standard does not apply to ammonia absorption refrigerating systems.

2.4 In cases of practical difficulty or unnecessary hardship, with approval by the jurisdictional authority, the use of other devices, materials or methods not included in this standard is permitted provided it is clearly evident that equivalent system performance and safety are thereby obtained.

Section 3

Definitions

Defined terms used in a definition are *italicized*.

actuator: Mechanism for transmission of movement or force.

air-cooled condenser: A *refrigerant condenser* in which heat removal is accomplished entirely by heat absorption by the air flowing over condensing surfaces. See also *condenser*, *double-pipe (tube-in-tube) condenser*, *desuperheater*, *evaporative condenser*, *shell-and-tube condenser*.

air-cooled desuperheater: That part of the system designed to cool the *ammonia refrigerant* vapor after it is discharged from the *compressor* and before it enters the *condenser*. It is provided with a means of forcing air circulation over the external surface of the *desuperheater* coil for the heat removal necessary to cool the *refrigerant* vapor on the inside of the tubes.

air duct: A tube or conduit used for conveying air. (The air passages of *self contained* systems are not air ducts.)

ammonia: *Refrigerant*-grade anhydrous *ammonia*.

approved: Acceptable to the jurisdictional authorities.

approved nationally recognized testing laboratory: A laboratory acceptable to the jurisdictional authorities; that provides uniform testing and examination procedures under established standards; is properly organized, equipped, and qualified for testing; and has a follow up inspection service of the current production of the *listed* products.

automatic expansion valve: A controlling device which regulates the flow of volatile liquid *refrigerant* into an *evaporator* of a *closed-circuit ammonia refrigerating system* and which is actuated by *evaporator* pressure.

automatic liquid refrigerant drain valve: See *highside float valve*.

booster compressor: A *compressor* for discharging to the suction of a higher-stage *compressor*. See also *compressor*, *positive displacement compressor*.

check valve: A *valve* allowing fluid flow in one direction only.

closed-circuit ammonia refrigerating system: A refrigerating system using mechanical compression to remove the *refrigerant* from the low pressure side and to deliver it to the high pressure side of the system.

compressor: A specific machine with or without accessories, for compressing *ammonia refrigerant* vapor. See also *booster compressor*, *positive displacement compressor*.

condenser: That part of a *closed-circuit ammonia refrigerating system* where *refrigerant* is liquefied by the removal of heat. See also *air-cooled condenser*, *double-pipe (tube-in-tube) condenser*, *desuperheater*, *evaporative condenser*, *shell-and-tube condenser*.

condenser coil: That part of a *condenser* constructed of pipe or tubing not enclosed in a *pressure vessel*.

control valve: All *valves* except *shut-off valves*.

controlled-pressure receiver: An intermediate pressure *receiver* used to flash-cool *refrigerant* and to control the feed pressure. See also *pressure vessel*.

design pressure: The specified working pressure for a specific part of a *closed-circuit ammonia refrigerating system*.

desuperheater: A device which provides sensible cooling to the *refrigerant* vapor.

direct expansion: *Evaporator* arrangement whereby liquid *refrigerant* is fed through an expansion *valve* or device and evaporates completely before leaving as vapor.

double-pipe (tube in tube) condenser/ desuperheater: A type of *condenser/desuperheater* constructed of one or more assemblies of two tubes, one within the other, in which *refrigerant* vapor is condensed/desuperheated either in the annular space or the inner tube. See also *air-cooled condenser*, *condenser*, *desuperheater*, *evaporative condenser*, *shell-and-tube condenser*.

downstream pressure regulator: A control *valve* which regulates the flow of oil or *refrigerant* gas or liquid through the device which is actuated toward open by a pressure falling below regulator set point downstream of the *valve*.

dual pressure relief device: Two *pressure relief devices* (*valves* or *rupture members*) mounted on a *three way valve* that allows one device to remain active while the other is isolated. See also *pressure relief device*, *pressure relief valve*.

evaporative condenser: A *condenser* that obtains cooling effect by the evaporation of water in an air stream on the external surface of the tubes for the heat removal necessary to liquefy *refrigerant* vapor on the inside of the tubes. See also *air-cooled condenser*, *double-pipe (tube-in-tube) condenser*, *desuperheater*, *condenser*, *shell-and-tube condenser*.

evaporator: That part of a *closed-circuit ammonia refrigerating system* designed to vaporize liquid *refrigerant* to produce refrigeration. See also *shell-and-tube evaporator*.

evaporator coil: That part of an *evaporator* constructed of pipe or tubing not enclosed in a *pressure vessel*.

evaporator pressure regulator: A control *valve* which regulates the flow of primarily gaseous *refrigerant* from an *evaporator* section and which is actuated toward open by a pressure above set point upstream of the *valve*.

exit: A passageway adjacent to the door through which people leave a building.

field test: A test performed in the field to prove system tightness.

forced feed oil lubrication: A lubrication system in which oil is provided by an internal or external mechanical oil pump. This does not include splash type or drip type *compressor* lubrication systems.

flow regulator: A control *valve* which regulates the flow of liquid through the device which is actuated by flow rate changes to maintain a predetermined flow rate.

highside: Those parts of a *closed-circuit ammonia refrigerating system* subjected to approximate *condenser* pressure.

highside float valve: A control *valve* which regulates the flow of *refrigerant* or oil. This type of *valve* is actuated open by a rising liquid level upstream of the *valve*.

hot gas bypass regulator: A control *valve* which regulates the flow of *refrigerant* gas which is actuated toward open by a pressure falling below regulator set point downstream of the *valve*.

informative appendix: An appendix that is not part of the standard but is included for information purposes only.

internal gross volume: The volume as determined from internal dimensions of the container, with no allowance for the volume of the internal parts.

listed: Equipment that has been tested and is identified as acceptable by an *approved nationally recognized testing laboratory*.

lowside: The parts of a *closed-circuit ammonia refrigerating system* subjected to approximate *evaporator* pressure and/or the high stage suction (interstage) pressure of a two stage system.

lowside float valve: A control *valve* which regulates the flow of volatile liquid *refrigerant* into an *evaporator*. This type of *valve* is actuated closed by a rising liquid level downstream of the *valve*.

machinery room: An enclosed space that is designed specifically to safely house refrigerating equipment which includes *compressors*, *refrigerant pumps* or other *refrigerant* liquid transfer equipment that raises the pressure of the refrigerant.

manufacturer: The company or organization that creates and affixes its name, trademark or trade name to a product.

MAWP: The maximum allowable pressure permitted on a *closed-circuit ammonia refrigerating system*.

mechanical refrigerating system: See: *closed-circuit ammonia refrigerating system*.

motorized valve: A *valve* operated by a motor.

normative appendix: An integral part of the mandatory requirements of the standard, which, for reasons of convenience, is placed after all other normative elements.

oil drain float valve: See *highside float valve*, except controlling oil.

piping: The interconnecting parts of a *closed-circuit ammonia refrigerating system* which contain and convey the *ammonia*. Piping includes pipe, flanges, bolting, gaskets, *valves*, fittings, the pressure-containing parts of other components such as expansion joints, strainers, filters, and devices which serve such purposes as mixing, separating, snubbing, distributing, metering or controlling flow, pipe hangers, supporting fixtures and structural attachments.

plate heat exchanger: Multiple corrugated plates arranged to form a discrete flow path within the boundary of the plates for each of the fluid media between which heat is transferred.

positive displacement compressor: A *compressor* in which an increase in pressure is attained by changing the internal volume of the compression chamber.

pressure imposing element: Any device or portion of the equipment used to increase the *refrigerant* pressure.

pressure limiting device: A pressure responsive mechanism designed to automatically stop the operation of the pressure imposing element at a predetermined pressure.

pressure relief device: A pressure actuated *valve* or *rupture member* designed to automatically relieve excessive pressure. See also *dual pressure relief device*, *pressure relief valve*.

pressure relief valve: A pressure actuated *valve* held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting, also called a *safety valve*. See also *dual pressure relief device*, *pressure relief device*.

pressure vessel: Any *refrigerant* containing receptacle in a *closed-circuit ammonia refrigerating system*.

EXCEPTIONS:

a. *Evaporators* where each separate *evaporator* section does not exceed 0.5 ft^3 (0.01 m^3) of *refrigerant* containing volume regardless of the maximum inside dimension

b. *Evaporator* coils
c. *Compressors*
d. *Condenser* coils
e. Controls
f. Headers
g. Pumps
h. *Piping*
i. *Plate heat exchangers*

See also *controlled-pressure receiver*, *receiver*.

proof test: Design confirmation by testing a production sample to verify that it will not fail when exposed to a predetermined pressure that exceeds its rated design pressure.

readily accessible: Capable of being reached safely and quickly for operation, repair, and inspection without requiring those to whom ready access is required to climb over or remove obstacles or to resort to the use of portable access equipment.

receiver: A *pressure vessel* in a *closed-circuit ammonia refrigerating system* designed to hold the varying volume of liquid *refrigerant* resulting from changes in system operating conditions. See also *pressure vessel*, *controlled-pressure receiver*.

refrigerant: *Ammonia* used for heat transfer in a *closed-circuit ammonia refrigerating system* applying the vapor-compression cycle.

refrigerant-pressure-actuated condenser water regulator: A device which regulates the flow of cooling water through a *condenser* and which is actuated toward open by *highside* pressure rising above the regulator set point.

refrigerant pump: A mechanical device for moving liquid *ammonia refrigerant* within a *closed-circuit ammonia refrigerating system*.

rupture member: A device that will rupture at a predetermined pressure differential.

saturation pressure: The pressure at which vapor and liquid can exist in equilibrium at a given temperature.

self closing valve: A manually-operated *stop valve* that will automatically return to the closed position by means of a spring or other device when the operating handle is released.

self contained system: A complete factory-assembled and-tested *closed-circuit refrigerating system* that is shipped in one or more sections and which has no *refrigerant*-containing parts that are joined in the field by other than companion or block *valves*.

set pressure: The pressure at which a *pressure relief device* or pressure control is set to operate.

shall (shall not): Term used where the provision is mandatory.

shell and tube condenser: A type of *condenser* with tubes secured into a tube sheet at one or both ends of an enclosing shell. See also *air-cooled condenser*, *double-pipe (tube-in-tube) condenser*, *condenser*, *evaporative condenser*, *desuperheater*.

shell and tube evaporator: A type of *evaporator* where tubes are enclosed in a shell. *Refrigerant* can be either in the shell or tubes. See also *evaporator*.

should (should not): Used where the provisions are not mandatory but are (are not) recommended good practice under most but not all conditions.

shut-off valve: Externally actuated *valve* solely designed to stop flow for the purpose of isolating a sub-section of the system, also referred to in practice as, but not limited to - "block," "hand," "service," or "stop" *valve*.

solenoid valve: *Control valve* actuated by an electrically charged coil, designed to functionally stop flow.

strainer: Pressure-containing component through which *ammonia* flows for the purpose of separating particulate matter from the flow stream.

subcooled: Reduced to a temperature below the saturation temperature for the existing pressure.

superheat: Additional sensible heat content in a vapor which raises the temperature of the vapor above the saturation temperature corresponding to its pressure.

test pressure: The pressure to which a piece of equipment or a system is subjected, according to pressure test or leak test procedures.

thermostatic expansion valve: A *control valve* which regulates the flow of *refrigerant* into an *evaporator* of a *closed-circuit ammonia refrigerating system* and which is actuated by changes in *evaporator* pressure and *superheat* of the *refrigerant* gas leaving the *evaporator*. The basic function is to control the amount of *superheat*.

three way valve: A manually operated *valve* with one inlet which alternately can stop flow to either of two outlets. A service *valve* for dual mounted *pressure relief valves*.

trained technician: An individual having adequate training and experience which qualify that individual to service, maintain and operate a *closed-circuit ammonia refrigerating system* according to written procedures.

ultimate strength: The highest stress level which the component can tolerate without rupture.

valve: A pressure-containing component that stops, permits, or controls flow. See also *piping*, *automatic expansion valve*, *automatic liquid refrigerant drain valve*, *check valve*, *control valve*, *downstream pressure regulator*, *dual pressure relief device*, *evaporator pressure regulator*, *flow regulator*, *highside float valve*, *hot gas bypass regulator*, *lowside float valve*, *motorized valve*, *oil drain float valve*, *pressure relief device*, *pressure relief valve*, *refrigerant-pressure-actuated condenser water regulator*, *self-closing valve*, *shutoff valve*, *solenoid valve*, *thermostatic expansion valve*, *three-way valve*.

welded joint: A gas tight connection, created by the joining of metal parts in a molten state.

Section 4

References

4.1 Normative References

4.1.1 American Society of Mechanical Engineers (ASME), Section VIII, Division 1, Governing edition, *ASME Boiler and Pressure Vessel Code*, Pressure Vessels, (S-VIII, D-1, ASME B&PVC).

4.1.2 American Society of Mechanical Engineers (ASME), ASME B31.5, 2006, *Refrigeration Piping and Heat Transfer Components*.

4.1.3 American Society of Testing and Materials (ASTM), Editions as shown below:

4.1.3.1 ASTM A53/A53M-04a, *Standard Specification for Pipe*, *Steel*, *Black and Hot-Dipped*, *Zinc-Coated*, *Welded and Seamless*;

4.1.3.2 ASTM A105/A105M-03, *Standard Specification for Carbon Steel Forgings for Piping Applications*;

4.1.3.3 ASTM A106/A106M-04b, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*;

4.1.3.4 WITHDRAWN STANDARD: A120-84, *Specification for Pipe*, *Steel*, *Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless for Ordinary Uses* (Withdrawn 1987, replaced by ASTM A53 [ref.4.1.3.1]);

4.1.3.5 ASTM A181/A181M-01, *Standard Specification for Carbon Steel Forgings*, *for General-Purpose Piping*;

4.1.3.6 ASTM A193/A193M-04c, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*;

4.1.3.7 ASTM A234/A234M-04, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service*;

4.1.3.8 ASTM A307-04, *Standard Specification for Carbon Steel Bolts and Studs*, *60,000 PSI Tensile Strength*;

4.1.3.9 ASTM A312/A312M-04b, *Standard Specification for Seamless*, *Welded*, *and Heavily Cold Worked Austenitic Stainless Steel Pipes*;

4.1.3.10 ASTM A320/A320M-04, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service*;

4.1.3.11 ASTM A333/A333M-04a, *Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service*;

4.1.3.12 ASTM A403/A403M-04, *Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*;

4.1.3.13 ASTM A420/A420M-04, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service*;

4.1.3.14 ASTM A575-96, *Standard Specification of Steel Bars*, *Carbon*, *Merchant Quality, M Grades*;

4.1.3.15 ASTM A707/A707M-02, *Standard Specification for Forged Carbon and Alloy Steel Flanges for Low-Temperature Service*.

4.1.4 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE), ANSI/ASHRAE Standard 15-2007, *Safety Standard for Mechanical Refrigeration*.

4.1.5 National Fire Protection Association (NFPA), NFPA Standard 70, *National Electric Code* (NEC), current edition.

4.1.6 U.S. Department of Transportation (US DoT), 49 CFR Part 172, *Hazardous Materials Regulations*, governing edition.

4.1.7 International Safety Equipment Association (ISEA), ANSI/ISEA Z358.1, *World Safety Standard for Emergency Eyewash and Shower Equipment*, 2009 edition.

4.2 Informative References

4.2.1 U.S. Government Printing Office, Federal Specification 0-A-445C, *Ammonia*, *Technical*.

4.2.2 International Institute of Ammonia Refrigeration (IIAR):

4.2.2.1 ANSI/IIAR 3-2005, *Ammonia Refrigeration Valves*;

4.2.2.2 IIAR Bulletin 114, *Guidelines for Identification of Ammonia Refrigeration Piping and System Components*, 1991;

4.2.2.3 IIAR *Piping Handbook* 2000 [with 2004 revisions], Chapter 7, *Insulation for Refrigeration Systems*, 2004.

4.2.3 Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Governing editions:

4.2.3.1 29CFR1910.212, *General Requirements for All Machines*;

4.2.3.2 29CFR1910.219, *Mechanical Power Transmission Apparatus*;

4.2.3.3 29CFR1910 subpart D, *Walking-Working Surfaces*;

4.2.3.4 29CFR 1926.1053, subpart X, *Ladders;*

4.2.3.5 29CFR1910.147, *Control of Hazardous Energy*, ("Lockout/Tagout");

4.2.3.6 29CFR 1926.56, subpart D, *Illumination.*

4.2.4 American Petroleum Institute (API), API Practice 520, Recommended Practice 520: Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries, Part I — Sizing and Selection, 2000.

4.2.5 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), ANSI/MSS Standard Practice SP 69-2003, *Pipe Hangers and Supports*, *Selection and Application*.

4.2.6 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), 2002 *ASHRAE Handbook — Refrigeration*, *System Practices for Ammonia Refrigerant*, Chapter 3, Pages 3.5 and 3.6.

Section 5

General Requirements

5.1 Refrigerant-Grade Anhydrous Ammonia Specifications

5.1.1 See Appendix J (Informative) for information regarding stress corrosion cracking with anhydrous ammonia.

5.1.2 See Appendix C (Informative) for additional information regarding the characteristics and properties of ammonia.

5.2 Minimum Design Pressure

Minimum design pressures are listed in this Standard where pertinent. However, design pressure shall not be less than the pressure arising under all operating, shipping, and standby conditions. When selecting the design pressure, suitable allowance shall be provided for setting pressure-limiting devices to avoid nuisance shutdowns and loss of refrigerant at maximum operating conditions.

5.3 Testing

5.3.1 Design Pressure

Every refrigerant containing component shall be tested and proven tight by the manufacturer at not less than the design pressure for which it is rated.

5.3.2 Ultimate Strength Requirements

Every pressure-containing component of a closed-circuit ammonia refrigerating system other than pressure vessels, piping, pressure gauges or control mechanisms, shall either:
a. be listed either individually or as part of refrigeration equipment by an approved nationally recognized testing laboratory; or
b. shall be designed, constructed and assembled to have an ultimate strength sufficient to withstand at least three times the design pressure for which it is rated.

EXCEPTION:
Secondary coolant sides of components exempted from the rules of the governing edition of Section VIII, ASME Boiler and Pressure Vessel Code [ref.4.1.1], shall be designed, constructed and assembled to have ultimate strength sufficient to withstand 150 psig [1030 kPa gage] or two times the design pressure for which they are rated, whichever is greater.

Verification of such strength shall be done by proof testing.

5.4 Materials

5.4.1 General

All materials used in the construction of the equipment designated in Sections 6–12 shall be suitable for ammonia refrigerant at the coincident temperature and pressure to which the component shall be subjected. No materials shall be used that will deteriorate because of the presence of ammonia refrigerant or lubricating oil, or a combination of both, or any normal contaminant such as air or water. Where external surfaces of the equipment are exposed to the corrosive effects of air, water or other media, such exposed materials must be suitable for the application.

5.4.2 Metallic Materials

Cast iron, malleable iron, nodular iron, steel, cast steel, and alloy steel may be used as governed by ASME B31.5-2006 [ref.4.1.2] or the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], as applicable.

5.4.2.1 Zinc, copper, and copper alloys shall not be used in contact with or for containment of ammonia. Copper-containing anti-seize and/or lubricating compounds shall not be used in contact with ammonia piping. Copper as a component of brass alloys may be used for bearings or other non-refrigerant-containment uses.

5.4.2.2 Other metallic materials, such as aluminum, aluminum alloys, lead, tin, and lead-tin alloys may be used if they conform to 5.4.1. Where tin and tin-lead alloys are used, the alloy composition shall be suitable for the temperatures of application.

EXAMPLE: Typical uses would be tubing, valves, gaskets, packing, and joint compounds.

5.4.3 Non-Metallic Materials

Packings, glass, plastics, and rubber may be used if they conform to 5.4.1.

5.5 Duplicate Nameplates

5.5.1 Where duplicate nameplates are required for pressure vessels and heat exchangers constructed in accordance with Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code [ref.4.1.1], they shall comply with the governing edition of paragraph UG-119(e) of that Code.

5.5.2 A duplicate nameplate, if used, shall be installed on the skirt, supports, jacket, or other permanent attachment to a vessel.

5.5.3 Duplicate nameplates shall be permanently marked “DUPLICATE.”

5.5.4 Duplicate nameplates shall be obtained only from the original equipment manufacturer or its assignee.

5.5.5 The installer shall certify to the manufacturer that the duplicate nameplate has been applied to the proper vessel, in accordance with the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(d). The installer shall provide a copy of the certification to the owner, who shall retain the copy with the U1A form for the vessel.

NOTE:
Appendix D (Informative) provides further information on duplicate nameplates.

Section 6

Compressors and Refrigerant Pumps

6.1 Compressors

This section applies to compressors which are applied to closed-circuit ammonia refrigerating systems.

Products covered by this section are rotary vane booster compressors, reciprocating booster and high stage compressors, rotary screw booster and high stage compressors and centrifugal booster and high stage compressors.

6.1.1 Design

6.1.1.1 Minimum design pressure for high stage compressors with water or evaporative cooled condensing shall be 250 psig [1720 kPa gage].

6.1.1.2 Minimum design pressure for high stage compressors with air cooled condensing shall be 300 psig [2070 kPa gage].

EXCEPTION:
For reciprocating compressors, minimum lowside design pressure shall be 250 psig [1720 kPa gage].

6.1.1.3 Minimum design pressure for booster compressors shall be 150 psig [1030 kPa gage].

6.1.2 Positive Displacement Compressor Protection

6.1.2.1 When equipped with a stop valve in the discharge connection, every positive displacement compressor shall be equipped with a pressure relief device selected to prevent the discharge pressure from increasing to more than 10% above the lowest of the maximum allowable working pressures of the compressor, any other components located in the path between the compressor, and the stop valve. Such pressure relief device shall be sized to accommodate the output of the compressor or in accordance with 11.2.7, whichever is larger. The pressure relief device shall discharge into the low pressure side of the system or in accordance with 11.3.6.2, 11.3.6.3, and 11.3.6.4.

The relief device shall be sized based on compressor flow at 50°F (10°C) saturated temperature at the compressor suction.

EXCEPTIONS:
a. For compressors capable of operating only when discharging to the suction of a higher-stage compressor, calculate flow at the saturated suction temperature equal to the design operating intermediate temperature.

b. When the compressor is equipped with automatic capacity regulation which actuates to minimum flow at 90% of the pressure relief device setting and a pressure-limiting device is installed and set in accordance with 11.2.7, the discharge capacity of the relief device is allowed to be the minimum regulated flow rate of the compressor.

NOTE:
Appendix E (Informative) describes one acceptable method of calculating the discharge capacity of positive displacement compressor pressure relief devices.

6.1.2.2 All positive displacement compressors shall be provided with high-discharge-temperature/low suction pressure and high-discharge-pressure limiting devices. Compressors using forced feed oil lubrication shall be provided with an indicating-type lubrication failure control. Except for booster compressors, high-pressure limiting devices shall be of the manual reset type. The setting of high-pressure limiting devices shall not exceed the lower of the compressor manufacturer's recommendation or 90% of the setting of the pressure relief device on the discharge side of the compressor. The setting of low pressure-limiting devices shall be the higher of:
a. The system's minimum design pressure to protect against freeze-up or other damage, or
b. The compressor manufacturer's recommendations.

6.1.2.3 All exposed rotating components (e.g., shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with approved safety standards [ref.4.2.3.2].

6.1.2.4 If rotation is to be in only one direction, a rotation arrow shall be cast in or permanently attached to the compressor frame.

6.1.2.5 For ultimate strength requirements, see 5.3.2.

6.1.3 Procedures/Testing

6.1.3.1 Strength Test. Compressors shall be hydrostatically tested by the manufacturer at a pressure not less than 1.5 times the design pressure for which they are rated.

6.1.3.2 Leak Test. Compressors shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

6.1.4 Equipment Identification

The following data shall be provided on nameplates or labels affixed to compressors:
a. Manufacturer's name
b. Manufacturer's serial number
c. Model number
d. Year of manufacture
e. Hydrostatic test pressure
f. Maximum allowable working pressure
g. Refrigerant "Ammonia"
h. Rotation speed in rpm, maximum and minimum for proper lubrication
i. Direction of rotation (where applicable; see 6.1.2.4)

6.2 Refrigerant Pumps

This section applies to mechanical pumps applied for use in closed-circuit ammonia refrigerating systems. This section does not apply to liquid refrigerant transfer or pumping systems employing pressure differential to move liquid refrigerant.

6.2.1 Design

6.2.1.1 Pump casing minimum design pressure requirements:

EXCEPTION:
Application design pressures which exceed these minima shall prevail.

a. High side service utilizing water-cooled or evaporative condensing: 250 psig [1720 kPa gage]
b. High side service utilizing air-cooled condensing: 300 psig [2070 kPa gage]
c. Low side service: 150 psig [1030 kPa gage].

6.2.1.2 A hydrostatic or differential pressure relief device (or noncloseable vent pipe) shall be used for pressure protection of a liquid pump and its associated piping. The inlet connection for the relief device or vent pipe shall be located on the pump casing or piping between the stop valves at the pump inlet and outlet, except that when a check valve is located between the pump and its outlet stop valve, the relief device or vent pipe inlet shall be connected to the pipe between the discharge check valve and stop

valve. The discharge of this relief or vent pipe shall connect either to the pump suction line upstream of the pump suction stop valve or to the vessel to which the pump suction is connected. This pressure relief device or vent pipe shall be external to the pump housing.

6.2.1.3 For ultimate strength requirements, see 5.3.2.

6.2.1.4 All exposed rotating components (e.g., shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with approved safety standards [ref.4.2.3.2].

6.2.2 Procedures/Testing

6.2.2.1 Strength Test. Ammonia pumps shall be hydrostatically tested by the manufacturer at a pressure not less than 1.5 times the design pressure for which they are rated.

6.2.2.2 Leak Test. Ammonia pumps shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

6.2.3 Equipment Identification

Manufacturers producing ammonia pumps shall permanently affix to the pump a nameplate providing the following minimum data:

a. Manufacturer's name
b. Manufacturer's serial number
c. Model number
d. Design pressure
e. Minimum operating temperature
f. Refrigerant "Ammonia"
g. Rotation speed in rpm, maximum (where applicable)
h. Direction of rotation (where applicable)
i. Electric motor rating, maximum (where applicable)
j. Electric heater rating(s), if supplied
k. Electric supply: volts, full load amps, frequency (Hz), phase (where applicable).

Section 7

Condensers

7.1 Air Cooled Condensers and Air Cooled Desuperheaters

This section applies to air cooled condensers and air cooled desuperheaters which are applied to closed-circuit ammonia refrigerating systems.

7.1.1 Design

7.1.1.1 Minimum design pressure shall be 300 psig [2070 kPa gage].

7.1.1.2 For ultimate strength requirements, see 5.3.2.

7.1.1.3 Where the refrigerant coil inlet and outlet lines of air cooled condensers and desuperheaters can be isolated, they shall be protected from hydrostatic pressure per 11.4.

7.1.1.4 All exposed rotating components (e.g., shafts, fans, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with approved safety standards [ref.4.2.3.2].

7.1.1.5 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

7.1.2 Procedures/Testing

Air cooled condensers and desuperheaters shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

7.1.3 Equipment Identification

The following data shall be provided on nameplates or labels affixed to the equipment:

EXCEPTION:
Nameplate data is not required on air cooled desuperheaters that are integral with condensers.

a. Manufacturer's name
b. Manufacturer's serial number
c. Model number
d. Year of manufacture
e. Design pressure
f. Direction of fan rotation
g. Electric motor power
h. Electric supply: volts, full load amps, frequency (Hz), phase.

7.2 Evaporative Condensers

This section applies to evaporative condensers which are applied to closed-circuit ammonia refrigerating systems.

7.2.1 Design

7.2.1.1 Minimum design pressure shall be 250 psig [1720 kPa gage].

7.2.1.2 For ultimate strength requirements see 5.3.2.

7.2.1.3 Pressure vessels incorporated into evaporative condensers shall comply with Section 9.

7.2.1.4 Where the refrigerant coil inlet and outlet lines of evaporative condensers can be isolated, the condenser shall be protected from refrigerant hydrostatic pressure per 11.4.

7.2.1.5 All exposed rotating components (e.g., fans, shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with governing safety standards [ref.4.2.3.2].

7.2.1.6 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

7.2.2 Procedures/Testing

Evaporative condensers shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

7.2.3 Equipment Identification

The following data shall be provided on nameplates or labels affixed to the equipment or components of the equipment:

a. Manufacturer's name
b. Manufacturer's serial number
c. Model number
d. Year of manufacture
e. Design pressure
f. Direction of fan rotation (and water circulating pump, if supplied)
g. Electric motor rating for fan(s) (and water circulating pump, if supplied)
h. Electric supply: volts, full load amps, frequency (Hz), phase.

7.3 Shell and Tube Condensers

This section applies to shell and tube condensers which are applied in closed-circuit ammonia refrigerating systems.

Products covered by this section are horizontal and vertical shell and tube condensers with closed water passes and vertical shell and tube condensers with open water passes.

7.3.1 Design

7.3.1.1 The refrigerant side maximum allowable working pressure shall be at least 250 psig [1720 kPa gage].

7.3.1.2 For secondary coolant side ultimate strength requirements, see 5.3.2.

7.3.1.3 Pressure vessels incorporated into shell and tube condensers shall comply with Section 9.

7.3.1.4 Where the refrigerant inlet and outlet lines of shell and tube condensers can be isolated, the refrigerant side shall be pressure-relief protected per 11.2.

EXCEPTION:
Where the condenser is not a pressure vessel it shall be protected from hydrostatic pressure per 11.4 in place of 11.2.

7.3.1.5 Where the secondary coolant inlet and outlet lines of shell and tube condensers can be isolated they shall be protected from hydrostatic pressure per 11.4.

7.3.2 Procedures/Testing

Shell and tube condensers shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

7.3.3 Equipment Identification

7.3.3.1 Manufacturers producing shell and tube condensers and double pipe condensers shall provide the following minimum data on a metal nameplate affixed to the equipment:
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by" on nameplates of integral ASME-stamped vessels)
d. Shell side maximum allowable working pressure _____ at _____ temperature
e. Tube side maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at _____ pressure
g. Tube side minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Type of construction (in accordance with 4.1.1, where applicable).

7.3.3.2 Manufacturers producing shell and tube condensers with integral pressure vessels (e.g., condensers with refrigerant in a shell qualifying as a pressure vessel) shall provide data in accordance with the relevant "UG" sections of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

7.3.3.3 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

7.4 Plate Heat Exchanger Condensers

This section applies to plate heat exchanger condensers which are applied in closed-circuit ammonia refrigerating systems.

Products covered by this section include plate heat exchanger condensers of the plate-and-shell type, and of the plate-and-frame type.

7.4.1 Design

7.4.1.1 The refrigerant side maximum allowable working pressure shall be at least 250 psig [1720 kPa gage].

7.4.1.2 For ultimate strength requirements, see 5.3.2.

7.4.1.3 Pressure vessels incorporated into plate heat exchanger condensers (e.g., the shell of a plate-and-shell condenser with refrigerant in a shell qualifying as a pressure vessel) shall comply with Section 9.

7.4.1.4 Where the refrigerant inlet and outlet lines of refrigerant-containing plate packs can be isolated, the refrigerant side of the plate pack shall be pressure-relief protected per 11.2.

EXCEPTION:
Where the condenser is not a pressure vessel, it shall be protected from hydrostatic pressure per 11.4 in place of 11.2.

7.4.1.5 Where the process fluid (i.e., non-refrigerant) inlet and outlet lines of plate packs can be isolated, they shall be protected from hydrostatic pressure per 11.4.

7.4.2 Procedures/Testing

Plate heat exchanger condensers shall be tested per the provisions of the governing edition of Section VIII, Division I, ASME Boiler and Pressure Vessel Code [ref. 4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

7.4.3 Equipment Identification

7.4.3.1 Manufacturers producing plate heat exchanger condensers shall provide the following minimum data on a metal nameplate affixed to the equipment.
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by," if the vessel is ASME-stamped)
d. Shell side maximum allowable working pressure _____ at_____ temperature (where applicable)
e. Plate pack maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at_____ pressure (where applicable)
g. Plate pack minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Test pressure (note test type; hydraulic or pneumatic)
l. Type of construction (in accordance with 4.1.1, where applicable).

7.4.3.2 Manufacturers producing plate heat exchanger condensers with integral pressure vessels (e.g., plate-and-shell heat exchangers with refrigerant in a shell qualifying as a pressure vessel) shall provide data in accordance with the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

7.4.3.3 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

7.5 Double-Pipe Condensers

This section applies to double-pipe condensers which are applied in closed-circuit ammonia refrigerating systems.

Products covered by this section are double-pipe condensers with closed water passes.

7.5.1 Design

7.5.1.1 The refrigerant side maximum allowable working pressure shall be at least 250 psig [1720 kPa gage].

7.5.1.2 For secondary coolant side ultimate strength requirements, see 5.3.2.

7.5.1.3 Pressure vessels incorporated into double-pipe condensers shall comply with Section 9.

7.5.1.4 Where the refrigerant inlet and outlet lines of double-pipe condensers can be isolated, the refrigerant side shall be pressure-relief protected per 11.2.

EXCEPTION:
Where the condenser is not a pressure vessel it shall be protected from hydrostatic pressure per 11.4 in place of 11.2.

7.5.1.5 Where the water inlet and outlet lines of double-pipe condensers can be isolated they shall be protected from hydrostatic pressure per 11.4.

7.5.2 Procedures/Testing

Double-pipe condensers shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

7.5.3 Equipment Identification

7.5.3.1 Manufacturers producing double-pipe condensers shall provide the following minimum data on a metal nameplate affixed to the equipment:
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by" on nameplates of integral ASME-stamped vessels)
d. Shell side maximum allowable working pressure _____ at _____ temperature
e. Tube side maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at _____ pressure
g. Tube side minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Type of construction (in accordance with 4.1.1, where applicable).

7.5.3.2 Manufacturers producing double-pipe condensers with integral pressure vessels (e.g., condensers with refrigerant in a shell qualifying as a pressure vessel) shall provide data in accordance with the relevant "UG" sections of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

7.5.3.3 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref. 4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

Section 8

Evaporators

8.1 Forced Air Evaporator Coils

This section applies to evaporator coils which are applied to closed-circuit ammonia refrigerating systems.

8.1.1 Design

8.1.1.1 Minimum design pressure shall be 150 psig [1030 kPa gage] or in the case where hot gas defrost is utilized, minimum design pressure shall be 250 psig [1720 kPa gage] or the design pressure of the high side source of hot gas, whichever is greater.

8.1.1.2 For ultimate strength requirements, see 5.3.2.

8.1.1.3 Where refrigerant coil inlet and outlet lines can be isolated, they shall be protected from hydrostatic pressure per 11.4.

8.1.1.4 All exposed rotating components (e.g., fans, shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with governing safety standards [ref.4.2.3.2].

8.1.1.5 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

8.1.2 Procedures/Testing

Evaporator coils shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

8.1.3 Equipment Identification

The following data shall be provided on nameplates or labels affixed to the equipment:
a. Manufacturer's name
b. Manufacturer's serial number
c. Model number
d. Year of manufacture
e. Design pressure
f. Direction of fan rotation (if supplied)
g. Electric motor size for fans (if supplied)
h. Electric defrost heater and drain pan heater ratings (if supplied)
i. Electric supply: volts, full load amps, frequency (Hz), phase.

8.2 Shell and Tube Evaporators (with refrigerant in shell)

This section applies to shell and tube evaporators which are applied to closed-circuit ammonia refrigerating systems at any temperature level when evaporating refrigerant is used to cool another fluid.

8.2.1 Design

8.2.1.1 The shell maximum allowable working pressure shall be at least 150 psig [1030 kPa gage] or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

8.2.1.2 Pressure vessels incorporated into shell and tube evaporators shall comply with Section 9.

8.2.1.3 Where the tube-side inlet and outlet lines of shell and tube evaporators with refrigerant in shell can be isolated, the tube side shall be protected from hydrostatic pressure per 11.4.

8.2.1.4 Heat loads from cleaning operations shall be considered when designing the relief capacity and control of process heat exchangers.

8.2.2 Procedures/Testing

Shell and tube evaporators shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

8.2.3 Equipment Identification

8.2.3.1 Manufacturers producing shell and tube evaporators for refrigerant in the shell shall provide data in accordance with the relevant "UG" sections of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], but in any case shall provide the following minimum data on a metal nameplate affixed to the equipment:
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by," if the vessel is ASME-stamped)
d. Shell side maximum allowable working pressure _____ at _____ temperature
e. Tube side maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at _____ pressure
g. Tube side minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Test pressure (note test type; hydraulic or pneumatic)

l. Type of construction (in accordance with 4.1.1, where applicable)
m. Additional pressure and temperature stamping with reference to vessels used below minimum design metal temperature (in accordance with 4.1.1, where applicable).

8.2.3.2 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

8.3 Shell and Tube Evaporators (with refrigerant in tubes)

This section applies to shell and tube evaporators which are applied to closed-circuit ammonia refrigerating systems at any temperature level when evaporating refrigerant is used to cool another fluid.

8.3.1 Design

8.3.1.1 The tube maximum allowable working pressure shall be at least 150 psig [1030 kPa gage] or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

8.3.1.2 Where the tube-side inlet and outlet lines of shell and tube evaporators (with refrigerant in tubes) can be isolated, the tube-side shall be pressure-relief protected per 11.2.

EXCEPTION:
Where the evaporator is not a pressure vessel, it shall be protected from hydrostatic pressure per 11.4 in place of 11.2.

8.3.1.3 Pressure vessels incorporated into shell and tube evaporators with refrigerant in tubes shall comply with Section 9.

8.3.1.4 Tube side shall comply with the rules of Section 5 of ASME B31.5-2006 [ref.4.1.2] or the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

8.3.1.5 Heat loads from cleaning operations shall be considered when designing the relief capacity and control of process heat exchangers.

8.3.2 Procedures/Testing

Shell and tube evaporators shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

8.3.3 Equipment Identification

8.3.3.1 Manufacturers producing shell and tube evaporators for refrigerant in the tubes shall provide the data in accordance with the relevant "UG" section of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], where applicable, and in any case shall provide the following minimum data on a metal nameplate affixed to the equipment:
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by," if the vessel is ASME-stamped)
d. Shell side maximum allowable working pressure _____ at _____ temperature
e. Tube side maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at _____ pressure
g. Tube side minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Test pressure (note test type; hydraulic or pneumatic)
l. Type of construction (in accordance with 4.1.1, where applicable)

m. Additional pressure and temperature stamping with reference to vessels used below minimum design metal temperature (in accordance with 4.1.1, where applicable).

8.3.3.2 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

8.4 Plate Heat Exchanger Evaporators

This section applies to plate heat exchanger evaporators which are applied to closed-circuit ammonia refrigerating systems.

Products covered by this section include plate heat exchanger evaporators of the plate-and-shell type, and of the plate-and-frame type in which the heat transfer plate stack is axially contained between two pressure plates and where the plate joints may be fully elastomeric, paired plate sets welded with adjacent sets elastomeric, fully welded, or fully nickel brazed.

8.4.1 Design

8.4.1.1 Minimum refrigerant side design pressure shall be 150 psig [1030 kPa gage] or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

8.4.1.2 For ultimate strength requirements, see 5.3.2.

8.4.1.3 Pressure vessels incorporated into plate heat exchanger evaporators (e.g., plate-and-shell designed with refrigerant in a shell qualifying as a pressure vessel) shall comply with Section 9.

8.4.1.4 Where the refrigerant inlet and outlet lines of refrigerant-containing plate packs can be isolated, the refrigerant side of the plate pack shall be pressure-relief protected per 11.2.

EXCEPTION:
Where the evaporator is not a pressure vessel, it shall be protected from hydrostatic pressure per 11.4 in place of 11.2.

8.4.1.5 Where the process fluid (i.e., non-refrigerant) inlet and outlet lines of plate packs can be isolated, they shall be protected from hydrostatic pressure per 11.4 on the process side.

8.4.1.6 Heat loads from cleaning operations shall be considered when designing the relief capacity and control of process heat exchangers.

8.4.2 Procedures/Testing

Plate heat exchanger evaporators shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

8.4.3 Equipment Identification

8.4.3.1 Manufacturers producing plate heat exchanger evaporators shall provide the following minimum data on a metal nameplate affixed to the equipment:
a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by," if the vessel is ASME-stamped)
d. Shell side maximum allowable working pressure _____ at _____ temperature (where applicable)
e. Plate pack maximum allowable working pressure _____ at _____ temperature
f. Shell side minimum design metal temperature _____ at _____ pressure (where applicable)
g. Plate pack minimum design metal temperature _____ at _____ pressure
h. Manufacturer's serial number
i. Model number (where applicable)
j. Year of manufacture
k. Test pressure (note test type; hydraulic or pneumatic)

l. Type of construction (in accordance with 4.1.1, where applicable)
m. Additional pressure and temperature stamping with reference to pressure-containing components used below minimum design metal temperature (in accordance with 4.1.1, where applicable).

8.4.3.2 Manufacturers producing plate heat exchanger evaporators incorporating pressure vessels (e.g., plate-and-shell evaporators with refrigerant in a shell qualifying as a pressure vessel) shall provide data in accordance with the "UG" section of Section VIII, Division 1, of the governing edition of the ASME Boiler and Pressure Vessel Code [ref.4.1.1], where applicable.

8.4.3.3 Nameplate mounting
a. The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).
b. Where duplicate nameplates are supplied, they shall comply with 5.5.

Section 9

Pressure Vessels

This section applies to high pressure and low pressure vessels which are applied for use in closed-circuit ammonia refrigerating systems.

EXCEPTION:
Application design pressures for refrigerant-containing pressure vessels incorporated into other equipment which exceed Section 9.1 minima shall prevail.

EXAMPLE: Pressure vessel shells of shell and tube evaporators.

9.1 Design

9.1.1 Pressure vessel maximum allowable working pressure shall not be less than:

9.1.1.1 High side service utilizing water cooled or evaporative condensing: 250 psig [1720 kPa gage];

9.1.1.2 High side service utilizing air cooled condensing: 300 psig [2070 kPa gage];

9.1.1.3 Low side service: 150 psig [1030 kPa gage].

EXCEPTION:
When ammonia liquid is to be transferred from pressure vessels by pressurized ammonia gas, the pressure vessel design pressure shall accommodate the maximum possible transfer pressure and take into account the lowest possible coincident metal temperature.

9.1.2 Pressure vessels exceeding 6 in [15 cm] inside diameter shall comply with the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] covering the requirements for design, fabrication, inspection and testing during construction of unfired pressure vessels.

NOTE:
For pressure vessels having inside diameters less than 6 in [15 cm], see 5.3.2 for ultimate strength requirements.

9.1.3 Pressure vessels shall be provided with adequate opening(s) for the attachment of pressure relief device(s) as required in 11.2.

9.1.4 Heads of pressure vessels shall be hot-formed or stress relieved after cold-forming.

NOTE:
It is recommended that high-side vessels receive post-weld heat treatment per Appendix J (Informative).

9.1.5 A vessel shall be designed and stamped with a MDMT (minimum design metal temperature) no higher than its lowest expected operating temperature.

9.1.6 In applications where vessels are subject to external corrosion, the vessels shall be designed and specified with a minimum of 1/16" [1.6 mm] corrosion allowance.

9.2 Procedures/Testing

Pressure vessels shall be tested per the provisions of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1], if applicable. Otherwise, they shall be tested and proven tight by the manufacturer at a pressure not less than the maximum allowable working pressure for which they are rated.

9.3 Equipment Identification

9.3.1 Manufacturers producing pressure vessels shall provide data in accordance with the requirements of the relevant "UG" sections of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref. 4.1.1], but in any case shall provide the following minimum data on a metal nameplate affixed to the equipment as specified in 9.3.2:

a. ASME stamp (where applicable)
b. National Board Number (where applicable)
c. Manufacturer's name (preceded by the words "certified by," if the vessel is ASME stamped)
d. Maximum allowable working pressure _____ at _____ temperature
e. Minimum design metal temperature _____ at _____ pressure
f. Manufacturer's serial number
g. Year of manufacture
h. Model number (where applicable)
i. Test pressure (note test type; hydraulic or pneumatic)
j. Type of construction (in accordance with 4.1.1, where applicable)
k. Additional pressure and temperature stamping with reference to vessels used below minimum design metal temperature (in accordance with 4.1.1, where applicable).

9.3.2 Nameplate mounting

9.3.2.1 The original nameplate shall be affixed to the equipment as specified in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1] paragraph UG-119(e).

9.3.2.2 Where duplicate nameplates are supplied, they shall comply with 5.5.

Section 10

Piping

10.1 The design, materials, fabrication, examination, and testing of the piping, whether fabricated in a shop or as a field erection, shall comply with ASME B31.5-2006, Refrigeration Piping [ref.4.1.2], except where noted.

10.2 Pipe, Fittings, and Flanges

10.2.1 Material

10.2.1.1 All pipe, flanges and fittings must be suitable for ammonia refrigerant at the temperature and pressure to which the component may be subjected.

10.2.1.2 No material may be used that will deteriorate because of the presence of ammonia refrigerant or lubricating oil.

10.2.1.3 Components in direct contact with ammonia shall not contain copper, brass, mercury, or alloys of these materials.

10.2.1.4 The materials referenced in Section 10.2 and subsections are the minimum allowable material specifications for ammonia system applications. Other materials shall be acceptable if the material properties are suitable for the intended duty and exceed the specifications noted.

10.2.1.5 Pipe

a. Carbon steel: ASTM A53 — Grade A or B, Type E or S [ref.4.1.3.1]
b. Carbon steel: ASTM A106 — Grade A or B [ref.4.1.3.3]
c. Stainless steel: ASTM A312 — Type 304,

304L, 316, or 316L [ref.4.1.3.9]
d. Carbon steel (low temperature): ASTM A333 — Grade 1 or 6 [ref.4.1.3.11].

ASTM A120 [ref.4.1.3.4], A53/A-120, A53 — Type F [ref. 4.1.3.1] pipe and cast iron or wrought iron pipe shall not be used for ammonia refrigeration service.

NOTE:
Carbon steel pipe, ASTM A53 [ref.4.1.3.1] or A106 [ref.4.1.3.3], may be used below –20°F if it either (1) is impact tested, or (2) meets a lower stress specification as determined through stress calculations: See ASME B31.5 — 2006, Refrigeration Piping [ref.4.1.2].

10.2.1.6 Fittings

All fittings shall match pipe schedules. Screwed fittings shall be forged or cast steel.
a. Carbon steel: ASTM A105 [ref.4.1.3.2]
b. Carbon steel: ASTM A234 [ref.4.1.3.7]
c. Stainless steel: ASTM A403 [ref.4.1.3.12]
d. Carbon steel (low temperature): ASTM A420 [ref. 4.1.3.13].

10.2.1.7 Flanges
a. Carbon steel: ASTM A105 [ref.4.1.3.2]
b. Carbon steel: ASTM A181 [ref.4.1.3.5]
c. Stainless steel: ASTM A403 [ref.4.1.3.12]
d. Carbon steel (low temperature): ASTM A707 [4.1.5].

10.2.1.8 Bolting
a. Carbon steel: ASTM A307 [ref.4.1.3.8]
b. Stainless steel: ASTM A193 [ref.4.1.3.6]
c. Alloy steel (low temperature): ASTM A320 [ref.4.1.3.10].

10.2.2 Minimum Pipe Wall Thickness

10.2.2.1 Carbon steel, welded.
a. 1½ inch and smaller — schedule 80
b. 2 inch through 6 inch — schedule 40
c. 8 inch through 12 inch — schedule 20
d. 14 inch and larger — schedule 10.

10.2.2.2 Carbon steel, threaded, shall be schedule 80 for all sizes.

10.2.2.3 Stainless steel, welded.
a. ¾ inch through 1½ inch — schedule 40
b. 2 inch and larger — schedule 10.

10.2.2.4 Stainless steel, threaded, shall be schedule 80 for all sizes.

EXCEPTION:
Stainless steel tubing and associated compression fittings.

EXAMPLE: Used for compressor lubrication lines; small bore pressure sensing lines; hydrostatic relief lines; etc.

10.2.3 The use of 1/2 inch and smaller pipe is not recommended. Where the use of 1/2 inch and smaller pipe is required in the engineering design, it shall be adequately supported and/or protected to prevent damage.

10.2.4 Pipe shall be new, clean and free of rust, scale, sand and dirt.

10.3 Refrigerant Valves

This section applies to the equipment and system design requirements for valves used in the ammonia-containing and the lubricant-containing parts of closed-circuit ammonia refrigerating systems.

EXCEPTIONS:
a. Valves within the refrigerant-containing envelope of other equipment such as slide valves in screw compressors;
b. Safety relief valves.

Refer to ANSI/IIAR 3 [ref.4.2.2.1] for the manufacturing design performance requirements of ammonia refrigeration valves and strainers.

10.3.1 Valves in Equipment and System Design

10.3.1.1 Valves shall be oriented in accordance with the respective manufacturer's specification.

EXCEPTIONS:
The equipment and system design drawing(s) shall clearly show:
a. The required valve orientation in all cases where normal fluid flow through the valve is opposite to the flow direction marking.
b. The required valve spindle/stem orientation where a specific orientation is necessary for proper operation of the system.

10.3.1.2 Valve gasket materials shall match valve manufacturer's specifications and be of the thickness specified. Flange bolts shall be tightened in accordance with 10.5.3.4.

10.3.1.3 Operating speed of control valve actuators shall be considered in the system design.

10.3.1.4 The de-energized mode of control valves shall be considered in system design.

10.3.2 Check valves installed upstream of other automatic valves have the potential to trap liquid. Provision for liquid removal, to facilitate maintenance, shall be located downstream of the check valve. See Section 11.4.

10.3.3 Strainers shall be fitted with provision for refrigerant removal to facilitate maintenance.

10.3.4 Shut-off valves used to isolate equipment, control valves, controls or other components from other parts of the system for the purpose of maintenance or repair shall be capable of being locked out.

NOTE:
Control valves and other valves without a manually operable and lockable actuating element intended to stop flow for isolation purposes are not shut-off valves.

EXAMPLE: Solenoid valves, check valves.

10.4 Piping Hangers and Supports

10.4.1 Piping hangers and supports shall carry the weight of the piping, as well as any other anticipated loads.

EXAMPLE: refrigerant weight; insulation; frost/ice; seismic/wind loads; personnel; etc.

10.4.2 Sway bracing shall be included where necessary.

10.4.3 Threaded hot rolled steel hanger rods shall meet or exceed ASTM A575-96 [ref.4.1.3.14].

10.4.4 Anchors, their attachment point and methods shall be sufficient to bear all loads.

NOTES:
a. ASME B31.5-2006 [ref.4.1.2] provides for certain minimum dimensions for hangers to guard against mechanical damage, corrosion, etc.
b. See Appendix F (Informative) for additional information.
c. Mechanically expanded concrete attachments should not be axially loaded.

10.4.5 For piping that is insulated, supports must be designed and/or the insulation must be selected to avoid damage to the insulation from compression.

10.5 Piping Fabrication and Assembly

10.5.1 Valves (or flange sets) with specialized tightening requirements shall be installed according to manufacturer's instructions.

10.5.2 Piping joints shall be supported and in alignment such that the joint assembly does not induce distortion and stress.

10.5.3 Flanges

10.5.3.1 The mating surfaces of the gasketed joints shall be parallel, aligned and perpendicular to the pipe axis, in good condition and free of debris and corrosion.

10.5.3.2 Gaskets shall be correctly dimensioned for the flange set.

10.5.3.3 Nuts, bolts, cap screws and washers shall meet manufacturer's requirements for the application. Bolt threads shall extend completely through the mating nut.

10.5.3.4 The fasteners shall be progressively tightened in a diametrically staggered (crisscross) pattern.

10.5.4 Threaded Joints
a. Thread compound used in threaded joints shall be suitable for service in an ammonia refrigerating system.
b. Threaded joints that require seal welding shall be made up without any thread compound.

10.6 Pipe Marking

All piping mains, headers and branches shall be identified as to the physical state of the refrigerant (that is, vapor, liquid, etc.), the relative pressure level of the refrigerant, and the direction of flow. The identification system used shall either be one established as a standard by a recognized code or standards body or one described and documented by the facility owner.

NOTE:
See IIAR Bulletin 114 [ref.4.2.2.2].

Section 11

Overpressure Protection Devices

11.1 Pressure Relief Devices

This section applies to pressure relief devices installed on closed-circuit ammonia refrigerating systems containing pressure vessels for the purpose of relieving excess pressure due to fire or other abnormal conditions.

11.1.1 Every closed-circuit ammonia refrigerating system shall be protected by a pressure relief device in accordance with the general requirements of ANSI/ASHRAE 15-2007 Section 9.4 [ref.4.1.4] excepting section 9.4.3 and in addition shall comply with the specific requirements set forth in this standard.

11.1.2 Stop valves, including full-flow stop valves, are permitted in a pressure relief piping system downstream of a pressure relief device. Where used, stop valves shall be locked open whenever any relief device upstream is in service. Pressure drop across the stop valve at the design maximum flow of the relief piping system or the rated relief device flow (for relief device isolation valves) shall be taken into consideration in the design of the relief piping system.

11.1.3 The system design shall provide for all pressure relief devices to be installed as nearly as practicable directly to the pressure vessel or other parts of the system protected thereby, so that they are accessible for inspection and repair.

11.1.4 All pressure relief devices shall be connected at the highest practical point on the vessel, but in any case above the highest anticipated liquid refrigerant level on the vessel.

EXCEPTIONS:
a. For hydrostatic pressure relief, see 11.4.
b. For oil drain pots and similar applications, connect at the highest point on the vessel.

11.1.5 Relief valves shall not be located in refrigerated spaces unless precautions are taken to prevent moisture migration into the valve body or relief vent line.

11.1.6 Setting of Pressure Relief Devices

11.1.6.1 Pressure Relief Valve Setting. All pressure relief valves shall be set to start to function at a pressure not to exceed the design pressure of the parts of the system protected.

11.1.6.2 Rupture Member Setting. All rupture members used in lieu of or in series with a relief valve shall have a nominal rated rupture pressure not to exceed the design pressure of the parts of the system protected. The conditions of application shall conform to the requirements of the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

Rupture members installed ahead of relief valves need not be larger but shall not be smaller than the relief valve inlet.

Provision shall be made to detect pressure build up between the rupture member and the relief valve due to leakage through the upstream device.

11.1.7 Marking of Relief Devices

11.1.7.1 All pressure relief valves for refrigerant-containing components shall be set and sealed by the manufacturer. Each pressure relief valve shall be marked by the manufacturer with the data required in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1]. If a pressure relief valve requires resetting, this shall be undertaken by the manufacturer or a company holding a valid testing certificate for this work.

11.1.7.2 Each rupture member for refrigerant containing pressure vessels shall be marked with the data required in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

11.1.7.3 The C_v [K_v] shall be stamped on the valve or available on request.

11.1.8 The capacity in SCFM [m^3/s] or the C_v [K_v] shall be stamped on the valve or available on request.

11.2 Pressure Vessel Protection

11.2.1 Pressure vessels shall be provided with pressure relief protection in accordance with rules given in the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1].

11.2.2 Pressure vessels containing liquid refrigerant that are capable of being isolated by stop valves from other parts of a closed-circuit ammonia refrigerating system shall be provided with overpressure protection. See also Section 11.4.

11.2.3 Pressure relief devices shall be sized in accordance with 11.2.7.

11.2.4 Pressure vessels less than 10 ft^3 [0.3 m^3] internal gross volume shall be protected by one or more pressure relief devices.

11.2.5 Pressure vessels of 10 ft^3 [0.3 m^3] or more internal gross volume shall be protected by at least one of the following options:

a. One or more dual pressure relief device(s). Dual pressure relief valves shall be installed with a three-way valve to allow testing or repair. When dual relief valves are used, each valve must meet the requirements of 11.2.7. When multiple dual relief valve assemblies are used,

i. the sum of the capacities of the pressure relief devices actively protecting the vessel must equal or exceed the requirements of 11.2.7, and

ii. the capacity of any dual relief assembly whose manifold valve is set to a position other than fully seated (one side open and one side closed) shall be counted to be zero.

b. A single pressure relief device, provided that: the vessel can be isolated and pumped out; the relief valves are located on the low side of the system; and other pressure vessels in the system are separately protected in accordance with 11.2.7.

11.2.6 When pressure relief valves are discharged into other parts of the closed-circuit ammonia refrigerating system, the system shall be equipped with pressure relief devices capable of discharging the increased capacity in accordance with 11.2.7 and the pressure relief valves discharging into the system shall be either:

a. A type not appreciably affected by back pressure, or

b. A type affected by back pressure, in which case its set pressure added to the set pressure of the system pressure relief device shall not exceed the design pressure of any component being protected.

11.2.7 The required discharge capacity of a pressure relief device for each pressure vessel shall be determined by the following equation:

$$\mathbf{C = 0.5\ DL\ (lb/min)}$$
$$\mathbf{[C = 0.04\ DL\ [kg/s]]}$$

where

C = required discharge capacity of the relief device, lb air/min [kg/s]
D = outside diameter of vessel, ft [m]
L = length of vessel, ft [m].

When one pressure relief device is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel. In the case of a plate heat exchanger, replace the DxL portion of the equation with a term equal to half the overall external surface area in square feet (m^2). In the case of a double-pipe condenser, replace the DxL portion of the equation with a term equal to half the overall external surface area in square feet (m^2).

NOTES:

a. When combustible materials are used within 20 ft (6.1 m) of a pressure vessel, the formula becomes C = 1.25 DL [C = 0.1 DL].

b. The formula is based on fire conditions. Other heat sources shall be calculated separately.

11.2.8 The rated discharge capacity of a pressure relief valve shall be determined in accordance with the governing edition of Section VIII, Division 1, ASME Boiler and Pressure Vessel Code [ref.4.1.1]. The capacity marked on the nameplate shall be in lb/min air or in standard ft^3/min (SCFM) of air at 60°F (SCFM x 0.0764 = lb/min of dry air).

11.2.9 The rated discharge capacity of a rupture member discharging under critical flow conditions shall be determined by the following equations:

$$\mathbf{C = 0.64\ P_1 d^2\ (lb/min)}$$
$$\mathbf{d = 1.25\ (C/P_1)^{0.5}\ (in)}$$
$$\mathbf{[C = 1.1 \times 10^{-6}\ P_1 d^2\ (kg/s)]}$$
$$\mathbf{[d = 959\ (C/P_1)^{0.5}\ (mm)]}$$

where

C = rated discharge capacity in lb/min [kg/s] of air

d = smallest of the internal diameter of the inlet pipe, retaining flanges or rupture member in inches [mm]

P_1 = rated pressure (psig) x 1.1 + 14.7 psi

[P_1 = rated pressure [kPa gage] x 1.1 + 101.3 kPa]

There shall be provisions to prevent plugging the piping in the event the rupture member relieves.

11.3 Pressure Relief Device Piping

Relief valve piping that discharges external to the closed-circuit ammonia refrigerating system is not part of the closed-circuit ammonia refrigerating system.

11.3.1 No stop valves shall be installed in the inlet or outlet piping of pressure relief devices unless procedures specified in the governing edition of the ASME Boiler and Pressure Vessel Code Section VIII Appendix M [ref.4.1.1] are followed.

11.3.2 The size of the inlet piping to a pressure relief device shall not be less than the inlet size of the pressure relief device.

11.3.3 The discharge piping from pressure relief devices shall be minimum schedule 40 steel for all pipe sizes. The relief piping shall comply with the materials requirements of 10.2.1.5, 10.2.1.6, 10.2.1.7 and 10.2.1.8.

EXCEPTION:
Relief piping is permitted to be galvanized or un-galvanized ASTM A120, A53/A120, or A53-Type F. It is recommended that when these grades of un-galvanized pipe are used, the pipe be clearly identified with paint striping to prevent their use in the closed refrigeration system.

11.3.4 The size of the discharge pipe from a pressure relief device shall not be less than the outlet size of the pressure relief device. The size and maximum equivalent length of common discharge piping downstream from each of two or more relief devices shall be governed by the sum of the discharge capacities of all the relief devices that are expected to discharge simultaneously, at the lowest pressure setting of any relief device that is discharging into the piping, with due allowance for the pressure drop in all downstream sections.

11.3.5 Where piping in the system and other components required to comply with this section may contain liquid refrigerant that can be isolated from the system during operation or service, 11.4 shall apply.

11.3.6 Atmospheric Discharge

Discharge from all atmospheric pressure relief valves/piping shall be to the outdoors.

11.3.6.1 The maximum length of the discharge piping installed on the outlet of pressure relief devices and fusible plugs discharging to the atmosphere shall be determined by the method in Appendix A (Normative). See Appendix A (Normative) Tables A.3 for the allowable flow capacity of various equivalent lengths of discharge piping for conventional safety relief valves.

11.3.6.2 Discharge piping from pressure relief devices piped to atmosphere shall have provision for draining moisture from the piping.

11.3.6.3 The extremity of the pressure relief device(s) discharge piping relieved to atmosphere shall be 20 ft [6.1 m] or more from any window, ventilation intake, or personnel exit, or as specified by the jurisdictional authority. The preferred direction of discharge is vertically upwards.

11.3.6.4 The discharge from pressure relief devices to the atmosphere shall be not less than 15 feet [4.8 m] above the adjacent grade or roof level or as specified by the jurisdictional authority and shall be arranged to avoid spraying of refrigerant on persons in the vicinity.

11.4 Equipment and Piping Hydrostatic Overpressure Protection

This section applies where specifically required by other sections in this standard and either of the following is true:
a. Equipment or piping sub-section(s) are isolated manually for any purpose, or
b. Equipment or piping sub-section(s) can be isolated automatically as a function of normal operation, shutdown [by any means, including alarm or power failure], standby, or equipment or component fault and can trap liquid refrigerant in the isolated section.

11.4.1 The manual isolation for any purpose of equipment and piping sub-section(s) shall be undertaken by trained technician(s) taking all necessary precautions to protect against overpressure due to hydrostatic expansion of trapped liquid refrigerant.

NOTE:
This typically involves the implementation of energy control procedures and training in compliance with OSHA 29CFR1910.147 [ref.4.2.3.5].

11.4.2 Equipment and piping sub-section(s) that can be isolated automatically in accordance with 11.4(b) shall be protected against overpressure due to hydrostatic expansion of trapped liquid refrigerant by either:
a. a hydrostatic relief device relieving to another part of the system or to an appropriately engineered location, or
b. an expansion compensation device.

NOTE:
See Appendix G (Informative).

11.4.3 Hydrostatic relief valves shall not be used as shut off valves (See 10.3.4.)

Section 12

Components and Controls

12.1 Visual Liquid Level Indicators: Bull's-Eyes, tubular glass and flat "armored glass" linear sight glasses/sight columns

12.1.1 All visual liquid level indicators used to observe the refrigerant level, such as in a vessel or heat exchanger, shall be installed in such a manner that they are protected from physical damage.

12.1.2 Linear liquid level indicators (sight columns) shall be fitted with internal check-type shutoff valves.

NOTE:
It is recommended that linear visual liquid indicators (sight columns) be of the flat "armored glass" type in preference to the tubular glass type.

12.2 Controls, Electric and Pneumatic

This section applies to sensing devices which initiate control pulses or signals applied for use in ammonia closed-circuit refrigerating systems.

Relay switches, contactors, and starters are not included in this section.

12.2.1 Design

12.2.1.1 Design of refrigerant containing parts shall meet the requirements of at least one of the following:
a. Be listed either individually or as part of an assembly or a system;
b. Prove satisfactory by successful performance under comparable service conditions;
c. Have a pressure-containment design based on an analysis consistent with the general design philosophy embodied in ASME B31.5-2006 [ref.4.1.2] and substantiated by one of the following:
i. Proof tests as described in UG-101 of Section VIII, Division 1, of the governing edition of the ASME Boiler and Pressure Vessel Code [ref.4.1.1];
ii. Experimental stress analysis.

12.2.1.2 Minimum design pressure for controls shall be 300 psig [2070 kPa gage].

EXCEPTION:
For controls designed specifically for and usable for lowside use exclusively, minimum design pressure shall be 150 psig [1030 kPa gage].

12.2.2 Procedures/Testing

12.2.2.1 Leakage Test. Each completely assembled control shall be subject to a manufacturer's refrigerant side bench test using air or other suitable fluid which will enable observation of leakage. Each control shall be proven tight at a pressure not less than the design pressure for which it is rated.

12.2.2.2 Functional Test. Each completely assembled control shall be subjected to a manufacturer's bench test which will simulate the field performance of the control in a manner which will determine that the completed device functions as designed or specified.

12.2.3 Equipment Identification

Manufacturers producing electrical and/or pneumatic controls shall provide the following minimum nameplate data:
a. Manufacturer's name
b. Manufacturer's serial number (where applicable)
c. Model number
d. Electric supply: volts, full load amps, frequency (Hz), phase (where applicable)
e. Pneumatic system: control range: maximum supply air pressure, minimum supply air pressure, required ACFM (where applicable)
f. Flow direction (where applicable)
g. Any special characteristics of a control device shall be noted either on the name tag or in the accompanying literature.

Section 13

Machinery Room Design

13.1 General

13.1.1 Construction

This section provides guidelines for the design of machinery rooms housing closed-circuit ammonia refrigerating machinery and vessels and accessories.

13.1.1.1 The building structure shall be designed to provide adequate strength and rigidity to house and support all compressors, accumulators, pumps and other equipment.

13.1.1.2 Where piping or equipment is supported by the roof or ceiling structure, the structure shall be designed to support the weight of all suspended piping or equipment.

13.1.1.3 Walls, floor, and ceiling shall be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigerating machinery room from other occupied spaces shall be of at least one-hour fire-resistive construction.

EXCEPTION:
Where the building is equipped with an automatic fire sprinkler system, one-hour fire-resistive construction shall not be required.

13.1.1.4 Foundations and supports for compressor units and other equipment located within the machinery room shall be of noncombustible construction and capable of supporting loads imposed by such units. Manufacturer's recommendations shall be considered.

13.1.1.5 All machinery shall be mounted in such a manner as to prevent excessive vibration from being transmitted to the building structure, or to connected equipment. Isolation materials such as rubber are permissible between the foundation and equipment.

13.1.1.6 There shall be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed in such a manner as to prevent any refrigerant leakage from entering the airstream. Access doors and panels in ductwork and air-handling units shall be gasketed and tight fitting.

13.1.2 Accessibility

13.1.2.1 Refrigerating systems shall be accessible to the Fire Department at all times as required by the fire code official.

13.1.2.2 A clear and unobstructed approach and space shall be provided to refrigerating machinery for inspection, service, and emergency shutdown with adequate clearances for maintenance of equipment. There shall be clear headroom of not less than 7.25 ft [2.21 m] below equipment situated over passageways.

13.1.2.3 All manually operated valves inaccessible from floor level shall be operable from portable platforms, fixed platforms, ladders, or shall be chain-operated. Isolation valve(s) identified as being part of an emergency shutdown procedure shall be directly operable or chain-operated from a permanent work surface.

13.1.2.4 Access to the refrigerating machinery room shall be restricted to authorized personnel. Doors shall be clearly marked and permanent signs shall be posted at each entrance to indicate this restriction.

13.1.3 Combustible Materials

13.1.3.1 Flammable and combustible materials shall not be stored in machinery rooms.

EXCEPTION:
This provision shall not apply to spare parts, tools and incidental materials necessary for the safe and proper operation and maintenance of the system.

13.1.4 Open Flames

13.1.4.1 Fuel-burning appliances and equipment having open flames and that use combustion air from the machinery room shall not be installed in a machinery room.

EXCEPTION 1:
Fuel-burning appliances shall not be prohibited in the same machinery room where combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber, or where a refrigerant vapor detector is employed to automatically shut off the combustion process in the event of refrigerant leakage.

EXCEPTION 2:
The use of matches, cigarette lighters, sulfur sticks, welding equipment and similar portable devices are permitted, other than during charging or discharging of oil or ammonia, where the machinery room meets the requirements of 13.3 Ventilation.

EXCEPTION 3:
Machinery rooms where internal combustion engines are used as the prime mover for the compressors.

13.1.5 Piping

13.1.5.1 Machinery or piping which could cause condensation or drips shall not be located over electrical equipment.

13.1.5.2 All pipes piercing the interior walls, ceiling or floor of the machinery room shall be tightly sealed to the walls, ceiling or floor through which they pass.

13.1.6 Eyewash/Shower

13.1.6.1 An eyewash and body shower unit shall be located external to the machinery room and readily accessible via an exit.

NOTE:
It is recommended that additional such units be located accessibly inside or outside the machinery room such that no unit is further than 10 seconds or 55 feet [16.8 m] from a hazard. Refer to ANSI/ISEA Z358.1 – 2009 for eyewash equipment guidelines.

13.1.7 Electrical Safety

13.1.7.1 Electrical equipment and wiring shall be installed in accordance with the National Electrical Code.

13.1.7.2 A machinery room shall be classified per the National Electric Code as a "Non-Hazardous (Unclassified) Location," when the machinery room is provided with an independent mechanical ventilation system operated according to 13.3 Ventilation.

13.1.7.3 Per the National Electric Code Where a mechanical ventilation system is not provided in accordance with 13.3, the room shall be classified as Class I, Group D, Division 2 location

13.1.8 Floor Drains

13.1.8.1 Adequate floor drains shall be provided to properly dispose of all wastewater. The accumulation of or the running of wastewater across the floor shall be kept to a minimum.

13.1.8.2 Wastewater shall be disposed in a manner approved by the authority having jurisdiction.

13.1.8.3 When required, a means shall be provided to prevent contamination of the drainage system.

13.1.9 Openings

13.1.9.1 Exterior openings shall not be under any fire escape or any open stairway.

13.1.10 Entrances and Exits

13.1.10.1 Each refrigerating machinery room shall have a tight-fitting door or doors opening outward, self-closing if they open into the building, and adequate in number to ensure freedom for persons to escape in an emergency.

13.1.10.2 Doors communicating with the building shall be approved, self-closing, tight-fitting fire doors equipped with panic-type hardware.

13.1.10.3 The refrigerating machinery room shall have a door that opens directly to the outside air or through a vestibule equipped with self-closing, tight-fitting doors equipped with panic-type hardware.

13.1.10.4 Refrigerating systems shall be provided with approved informative signs, emergency signs, charts and labels in accordance with NFPA 704. Hazard signs shall be in accordance with the International Mechanical Code.

NOTE:
Refer to informative Appendix L for an example.

13.1.11 Lighting

13.1.11.1 Compressor or machinery rooms shall be equipped with light fixtures to provide a minimum of 30 ft-candles [320 lumens/m2] at the working level, 36 in [0.9 m] above the floor or platform.

13.1.11.2 Condensers, receivers and other outside refrigerating equipment shall have lighting per OSHA guidelines to permit adequate nighttime inspection.

13.1.13 Refrigeration Machinery Remote Controls

NOTE:
Refer to section 13.3.11 for Ventilation Remote Controls

13.1.13.1 Refrigerant compressors, refrigerant pumps, and normally closed automatic refrigerant valves within the machinery room shall be de-energized at a concentration not exceeding 40,000 PPM (25% LFL).

13.1.13.2 A remote emergency shutdown control for refrigerant compressors, refrigerant pumps, and normally closed automatic refrigerant valves within the machinery room, shall be provided immediately outside the designated principle exterior machinery room door. The remote control shall be a clearly identified switch of the break glass type or with an approved tamper resistant cover, and it shall provide emergency off only control.

13.2 Refrigerant Detection

Each refrigerating machinery room shall contain at least two refrigerant detectors that actuate an alarm and mechanical ventilation.

13.2.1 Alarm

13.2.1.1 A monitored location shall be notified when the ammonia leak detector is activated so that corrective action can be taken.

NOTE:
"Monitored" is defined as a means of continual oversight such as pagers, on-site staff, third party alarm service or a responsible party.

13.2.1.2 The detectors shall activate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room.

13.2.2 Placement

13.2.2.1 The detectors, or sampling tubes that draw air to the detectors, shall be located in an area where refrigerant from a leak is likely to concentrate.

13.2.3 Detection Levels

13.2.3.1 One detector shall be utilized to activate an alarm and actuate the normal mechanical ventilation system (at its maximum design capacity) at a value not greater than the corresponding TLV-TWA.

13.2.3.2 The second detector shall be utilized to activate an alarm and actuate the emergency mechanical ventilation system at a level not exceeding 1000 ppm. Note: Additional ammonia detectors can be utilized to monitor refrigerant levels exceeding the range of the detectors in 13.2.3.1 and 13.2.3.2.

13.2.4 Signage

13.2.4.1 The meaning of each alarm shall be clearly marked by signage near the visual and audible alarms.

13.2.5 Testing

13.2.5.1 The facility shall establish a time schedule for testing of the ammonia detectors and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience

13.2.5.2 Where no recommendations are provided, these devices shall be functionally tested on an annual basis.

13.3 Ventilation

13.3.1 Each refrigerating machinery room shall be vented to the outdoors by means of mechanical ventilation systems actuated automatically by refrigerant detector(s), temperature sensors, and also operable manually. The mechanical ventilation systems shall be designed to produce a normal ventilation rate as required by Section 13.3.8, and an emergency ventilation rate as required by section 13.3.9. The mechanical ventilation systems shall be powered independently of the machine room machinery, and shall not be subject to emergency shutdown controls.

13.3.2 Multiple fans or multispeed fans are allowed in order to produce the emergency ventilation rate and to obtain a reduced airflow for normal ventilation. (See Section 13.3.8) Ventilation fans shall be selected such that the failure of any single fan does not diminish the total ventilation rate to less than 20 Air Changes per Hour (ACH). Fans that are used for normal ventilation and which are also used for emergency ventilation must be controlled such that the emergency rate is achieved when required, regardless of room temperature.

13.3.3 Inlet Air

Provision shall be made for inlet air to replace that being exhausted. Inlet air makeup shall be designed to provide a negative pressure in the machinery room with a maximum negative pressure of 0.25 in. water column.

13.3.3.1 Openings for inlet air shall be suitably guarded.

13.3.3.2 Openings for inlet air shall be positioned to be near the machinery, to avoid recirculation of exhausted air, and to avoid inducing anything except for clean, uncontaminated ambient air.

13.3.3.3 Inlet air ducts to the machinery room shall serve no other area and shall be covered with corrosion-resistant screen of not less than ¼ -inch (6.4 mm) mesh.

13.3.3.4 If motorized dampers are utilized they shall be of the power to close and spring to open type.

13.3.4 Discharge

13.3.4.1 The discharge of the air shall be to the outdoors in such a manner as not to cause a nuisance or danger, taking into account the natural airflow around the building, prevailing wind and surrounding structures.

13.3.4.2 Exhaust from mechanical ventilation systems shall be discharged not less than 20 feet (6 m) from a property line or openings into buildings.

13.3.4.3 Discharge air ducts from the machinery room shall serve no other area.

13.3.7 Exhaust Fans

13.3.7.1 All exhaust fans shall discharge up vertically with a minimum discharge velocity of 2500 FPM.

13.3.7.2 All exhaust fans shall be equipped with non-sparking blades.

13.3.7.3 All exhaust fan motors located in the air stream or inside of the building shall be of the totally enclosed type.

13.3.8 Normal Mechanical Ventilation

13.3.8.1 Normal mechanical ventilation design capacity shall be the greater of:

a. 20 Air Changes per hour (20 ACH) based on the total gross volume of the machinery room.

b. The volume required to limit the room temperature to 104°F (40°C) taking into

account the ambient heating effect of all machinery in the room and with the ventilation air entering the room at a 1% ASHRAE design. In the areas where ambient conditions could exceed 99°F, the emergency ventilation system is permitted to be used to supplement the normal ventilation during extreme conditions.

EXCEPTION:
A reduced normal ventilation rate can be used on applications where a means of cooling is provided or room electrical equipment is designed to accommodate temperatures exceeding 104°F (40°C), in accordance with UL and NEC standards.

13.3.8.2 To obtain the reduced airflow to maintain space temperatures for normal ventilation, partial operation of a multiple fan system or multi-speed fans can be utilized.

13.3.8.3 Normal ventilation need not be continuous and shall be actuated by:

a. Space temperature (thermostat).

b. A refrigerant detector at a value not greater than the corresponding TLV-TWA.

c. Manual controls.

13.3.9 Emergency Mechanical Ventilation

13.3.9.1 Emergency mechanical ventilation systems shall be capable of providing at least one air change every two minutes, which is 30 air changes per hour (30 ACH) based on the gross machinery room volume.

13.3.9.2 Emergency mechanical ventilation shall be actuated by

a. A refrigerant detector at a level not exceeding 1000 ppm.

b. Manual controls

13.3.10 Alarm on Failure

13.3.10.1 A monitored location shall be notified when either the normal or emergency mechanical ventilation system fails so that corrective action can be taken.

NOTE:
"Monitored" is defined as a means of continual oversight such as pagers, on-site staff, third party alarm service or a responsible party.

13.3.11 Ventilation Remote Controls

13.3.11.1 Emergency remote controls for the emergency mechanical ventilation systems shall be provided and be located immediately outside the designated principle exterior machinery room door.

13.3.11.2 The function of the emergency remote controls shall be clearly marked by signage near the controls.

13.3.11.3 Provide an "ON / Auto" override for emergency ventilation immediately outside the designated principle exterior machinery room door.

13.3.11.4 Provide an "ON / OFF / Auto" override for normal and emergency ventilation at a secured remote location.

13.3.12 Testing

13.3.12.1 The facility shall establish a time schedule for testing of the mechanical ventilation systems and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience.

13.3.12.2 Where no recommendations are provided, these devices shall be scheduled for functional tests on an annual basis.

Section 14

System Design

14.1 Purging

Means shall be provided to separate, collect, and remove air and other noncondensible gases from the refrigeration system, either automatically or manually, unless prohibited by governing regulations.

NOTE:
See Appendix I (Informative) for additional information.

14.2 Oil Removal

Provisions shall be made for removing oil from piping and equipment where oil is likely to collect.

14.2.1 Detailed operating procedures suitable for each drain point shall be provided for oil draining operations. Safety and personal protective equipment shall be specified.

14.2.2 Oil draining shall be conducted only by trained technicians and shall not be left unattended while in process.

EXCEPTION:
Permanently piped automatic return systems.

14.2.3 Oil removal shall be accomplished by one or more of the following:

a. A rigid piped oil return system.

b. A vessel equipped with an oil drain valve in series with either a self-closing or manual quick-closing emergency stop valve connected to the oil drain point, a vent line, a vent line isolation valve, and an approved pressure relief device.

c. Piping which provides capability for isolation and refrigerant removal to another portion of the system.

d. An oil drain valve in series with a self-closing or manual quick-closing emergency stop valve. When draining to atmosphere, rigid piping routing the oil 2 to 4 ft [0.6 to 1.2 m] away from and within sight of the valves shall be provided. Use of temporarily attached rigid piping and emergency stop valves is permitted.

e. Any other suitably engineered system.

14.3 Insulation

14.3.1 Suction lines, low-temperature liquid lines, accumulators, surge drums and similar cold surfaces shall be insulated to prevent condensation and corrosion.

EXCEPTION:
Cold surfaces in valve groups or in equipment shall be permitted to be left uninsulated to accommodate access for service, provided the vapor retarder is sealed to the piping or equipment.

14.3.2 Hot discharge lines less than 7.5 ft [2.3 m] high and near passageways or aisles shall be covered to reduce surface temperatures to tolerable limits or shall be suitably guarded.

NOTE:
See Appendix H (Informative) for additional information.

14.4 Foundations and Equipment Supports

14.4.1 Supports and foundations shall be adequate to prevent detrimental vibration, movement, and any site-specific external loads.

14.4.2 Such supports shall conform to the manufacturer's recommendations.

Section 15

Testing and Charging

15.1 Field Leak Testing

15.1.1 Upon complete installation of or revision to a closed-circuit ammonia refrigerating system, the system or affected part shall be tested for leaks before charging.

This field leak testing program for closed-circuit ammonia refrigerating systems is designed to assure a tight system which will operate without any appreciable loss of refrigerant.

15.1.2 Preparation

All joints shall remain unpainted and uninsulated until field leak testing has been completed.

Prior to testing, the following preparations shall be made:
a. Valve off and isolate from any test pressures all refrigeration compressors, liquid pumps, pressure switches and pressure transducers.
b. Remove all safety pressure relief devices and cap or plug the openings.
c. Open all solenoid, pressure-regulating, check or other control devices by means of their manual lifting stems.
d. Open all other valves except those leading to the atmosphere.
e. Cap, plug, or lock shut all valves and devices leading to the atmosphere.

15.1.3 The test gas shall be introduced into the system through the charging valve, or other suitable injection point fitted with a stop valve. The test pressure shall be verified using a calibrated pressure gauge located on the part of the system being tested. No leak repairs shall be made while that part of the system is under pressure.

15.1.4 The system ammonia compressor(s) shall not be used as a source of pressure for the field leak testing.

15.1.5 A suitable dry gas such as nitrogen or air shall be used for field leak testing per 15.1.6 and 15.1.7. The following fluids shall not be used for field leak testing an ammonia system:
a. Oxygen or any combustible gas or combustible mixture of gases
b. Carbon dioxide
c. Halocarbon refrigerants
d. Water or water solutions.

15.1.6 Leak Test

15.1.6.1 The highside and lowside of the system shall be tested at the greater of:
a. The relevant leak test pressure shown in Appendix B, and
b. The design pressure for that part of the system.

15.1.6.2 Dry nitrogen or compressed air or a combination of compressed air and dry nitrogen shall be used to raise the pressure in the ammonia system to that required for this test with the following provisions:

a. There shall be a suitable regulator located between the pressure source and the ammonia system to control the supply pressure.
b. There shall be a suitable relief device located on the ammonia system side of the regulator rated for the full discharge capacity of the compressor when an air compressor is used as the pressure source.
c. There shall be a suitable relief device located on the ammonia system side of the regulator rated for the full discharge capacity of the regulator when a nitrogen cylinder or tank is used as the pressure source.

15.1.6.3 All discovered leaks shall be repaired, all defective material shall be replaced and the test procedure repeated until the system is proven tight with respect to this test.

15.1.6.4 Upon completion of the leak tests, all preparations undertaken in 15.1.2 shall be reversed.

15.1.7 Ammonia Test

15.1.7.1 Approved ammonia safety equipment shall be available for the duration of the ammonia leak test in case of an emergency.

15.1.7.2 Upon satisfactory completion of the leak test the system shall be evacuated to a minimum of 10 in mercury [250 mm Hg] vacuum.

15.1.7.3 Sufficient ammonia vapor shall be introduced into the system to raise the system pressure to 100 psig [690 kPa gage] test pressure. If this test pressure cannot be achieved because the ambient temperature is too low, then the pressure shall be raised from the temperature equilibrium pressure of the ammonia to the test pressure using dry nitrogen.

15.1.7.4 The system shall be carefully inspected for leaks. All discovered leaks shall be repaired, all defective welds shall be repaired and the test procedure repeated until the system is proven tight with respect to the ammonia leak test. The system shall be maintained at test pressure for a minimum of 24 hr total ammonia test time.

15.1.7.5 If the ammonia test pressure is boosted with dry nitrogen, the system shall be evacuated to a minimum of 10 in mercury [250 mm Hg] vacuum before charging.

15.1.8 Purging

The system shall be purged to remove all noncondensible gases which remain after field leak testing.

NOTE:
See Appendix I (Informative) for additional information.

15.2 Ammonia Handling and Storage

15.2.1 Anhydrous ammonia shall be stored in, charged from or removed to approved portable cylinders, tank trucks or railroad tank cars.

NOTE:
See US DoT 49 CFR Part 172 [ref.4.1.6].

15.2.1.1 The closed-circuit refrigerating system shall have a valved connection to permit charging ammonia into either the highside liquid receiver, liquid line or lowside liquid receiver.

15.2.1.2 The unloading or charging operation shall be performed under continuous supervision.

15.2.1.3 Under no circumstances shall heat be applied directly to a storage cylinder or tank.

15.2.1.4 Ammonia handling and storage shall be performed by trained technicians.

15.2.2 Unloading or charging lines shall be suitable for ammonia service and capable of withstanding 350 psig [2410 kPa gage] working pressure and shall conform to Section 10.

15.2.3 Closed-circuit ammonia refrigerating system storage vessels shall meet the construction requirements of Section VIII, Division 1, of the governing edition of the ASME Boiler and Pressure Vessel Code [ref.4.1.1] and be designed for at least 250 psig [1720 kPa gage] maximum allowable working pressure.

15.2.4 Transfer of ammonia shall be by pump suitable for ammonia service or by pressure differential.

15.2.4.1 Flexible connections shall be used to transfer ammonia between the closed-circuit ammonia refrigerating system charging connection and a portable cylinder, tank truck or railroad tank car.

15.2.4.2 Rail cars and tank trucks shall be blocked and proper warning signs put in place before ammonia transfer connections are made.

15.2.4.3 Empty tanks or cylinders or cylinders under vacuum shall not remain connected to the closed-circuit refrigerating system after transfer operations are completed.

Section 16

Sources of References (Informative)

1. American National Standards Institute (ANSI)
   25 West 43rd Street, 4th Floor
   New York, NY 10036
   www.ansi.org
2. American Petroleum Institute (API)
   1220 L Street NW
   Washington, DC 20005-4070
   www.api.org
3. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
   1791 Tullie Circle, N.E.
   Atlanta, GA 30329
   www.ashrae.org
4. American Society of Mechanical Engineers (ASME)
   ASME International
   Three Park Avenue
   New York, NY 10016-5990
   www.asme.org
5. American Society of Testing and Materials (ASTM)
   ASTM International
   100 Barr Harbor Drive
   P.O. Box C700
   West Conshohocken, PA 19428-2959
   www.astm.org
6. International Institute of Ammonia Refrigeration (IIAR)
   1001 N. Fairfax St., Suite 503
   Alexandrai, VA 22314
   www.iiar.org
7. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
   127 Park Street, N.E.
   Vienna, VA 22180
   www.mss-hq.com
8. National Fire Protection Association (NFPA)
   60 Batterymarch Park
   Quincy, MA 02169-7471
   www.nfpa.org
9. U. S. Government Printing Office (GPO)
   Superintendent of Documents
   732 N. Capitol Street, NW
   Washington, DC 20401
   www.gpo.gov
10. U. S. Department of Labor/OSHA
    Publications Department
    200 Constitution Avenue, NW, Room N3101
    Washington, DC 20210
    www.osha.gov
11. U. S. Department of Transportation (US DoT)
    Research and Special Programs Administration
    Office of Hazardous Materials Safety
    400 7th Street, S.W.
    Washington, DC 20590
    www.dot.gov

Appendix A (Normative)

Allowable Equivalent Length of Discharge Piping

(This is a normative appendix and is part of this standard.)

The design back pressure due to flow in the discharge piping at the outlet of pressure relief devices and fusible plugs, discharging to atmosphere, shall be limited by the allowable equivalent length of piping determined by Equation 1 or Equation 2. See Tables A.3 for the precalculated flow capacity of various equivalent lengths of discharge piping for conventional relief valves.

$$L = \frac{0.2146 d^5 \left(P_0^2 - P_2^2\right)}{f C_r^2} - \frac{d \times \ln\left(P_o / P_2\right)}{6f}$$

Equation 1: Allowable relief discharge piping length, English units

$$\left[L = \frac{7.4381 \times 10^{-15} d^5 \left(P_0^2 - P_2^2\right)}{f C_r^2} - \frac{d \times \ln\left(P_o / P_2\right)}{500 f} \right]$$

Equation 2: Allowable relief discharge piping length, SI units

where

L = equivalent length of discharge piping, ft [m];

C_r = rated capacity as stamped on the relief device in lb/min [kg/s], or in SCFM multiplied by 0.0764, or as calculated in ANSI/ASHRAE 15-2007 par.9.7.7 for a rupture member or fusible plug, or as adjusted for reduced capacity due to piping as specified by the manufacturer of the device, or as adjusted for reduced capacity due to piping as estimated by an approved method;

f = Moody friction factor in fully turbulent flow (see typical values below);

d = inside diameter of pipe or tube, in [mm];

ln = natural logarithm;

P_2 = absolute pressure at outlet of discharge piping, psi [kPa];

P_0 = allowed back pressure (absolute) at the outlet of pressure relief device, psi [kPa].

For the allowed back pressure (P_0), use the percent of set pressure specified by the manufacturer, or, when the allowed back pressure is not specified, use the following values, where

P is the set pressure:

a. for conventional relief valves, 15% of set pressure, P_0 = (0.15 P) + atmospheric pressure;
b. for balanced relief valves, 25% of set pressure, P_0 = (0.25 P) + atmospheric pressure;
c. for rupture members, fusible plugs, and pilot operated relief valves, 50% of set pressure, P_0 = (0.50 P) + atmospheric pressure.

NOTE:
For fusible plugs, P is the saturated absolute pressure for the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, psi [kPa] and atmospheric pressure is at the elevation of the installation above sea level. A default value is the atmospheric pressure at sea level, 14.7 psi [101.325 kPa].

Typical Moody friction factors (*f*) for fully turbulent flow:

Tubing OD (in.)	DN	ID (in.)	*f*
⅜	8	0.315	0.0136
½	10	0.430	0.0128
⅝	13	0.545	0.0122
¾	16	0.666	0.0117
⅞	20	0.785	0.0114
1⅛	25	1.025	0.0108
1⅜	32	1.265	0.0104
1⅝	40	1.505	0.0101

A.1: Typical Moody Friction Factors, Steel Tubing

Piping NPS	DN	ID (in.)	*f*
½	15	0.622	0.0259
¾	20	0.824	0.0240
1	25	1.049	0.0225
1¼	32	1.380	0.0209
1½	40	1.610	0.0202
2	50	2.067	0.0190
2½	65	2.469	0.0182
3	80	3.068	0.0173
4	100	4.026	0.0163
5	125	5.047	0.0155
6	150	6.065	0.0149

A.2: Typical Moody Friction Factors, Steel Piping

Tables A.3: Discharge Capacity Tables

Safety relief valve discharge line capacity (lb/min air)of various line lengths, pipe sizes, and relief valve set pressures

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
5	*2*	2.8	5.8	10.7	21.3	31.4	57.8	88.8	148	279	469	704
5	*3*	2.3	4.8	9	18.1	26.8	49.9	77.3	130	250	426	647
5	*4*	2	4.2	7.9	16	23.7	44.5	69.4	118	228	393	601
5	*5*	1.8	3.8	7.1	14.4	21.5	40.6	63.5	108	211	367	564
5	*6*	1.7	3.5	6.6	13.3	19.8	37.5	58.9	101	198	346	533
5	*8*	1.5	3	5.7	11.6	17.4	33.1	52	89.5	177	312	484
5	*10*	1.3	2.7	5.1	10.5	15.7	29.9	47.1	81.3	162	286	446
5	*15*	1.1	2.2	4.2	8.6	12.9	24.7	39.2	67.9	136	243	380
5	*20*	0.9	1.9	3.7	7.5	11.3	21.6	34.2	59.4	120	214	337
5	*25*	0.8	1.7	3.3	6.7	10.1	19.4	30.8	53.5	108	194	306
5	*30*	0.8	1.6	3	6.2	9.3	17.8	28.2	49.1	99.1	179	282
5	*40*	0.7	1.4	2.6	5.3	8	15.4	24.5	42.8	86.5	156	247
5	*60*	0.5	1.1	2.1	4.4	6.6	12.6	20.1	35.1	71.2	129	205
5	*100*	0.4	0.9	1.7	3.4	5.1	9.8	15.6	27.3	55.6	101	160
5	*160*	0.3	0.7	1.3	2.7	4	7.8	12.4	21.7	44.1	80	127
5	*250*	0.3	0.6	1	2.1	3.2	6.2	9.9	17.4	35.3	64	102

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
15	*2*	4.6	9.3	16.7	32	46	81.6	113	197	355	577	849
15	*3*	3.9	8	15.5	28.3	41	74	112	182	335	550	815
15	*4*	3.5	7.1	13	25.6	37.4	68.1	104	171	317	526	784
15	*5*	3.1	6.5	11.9	23.6	34.6	63.5	97.1	161	302	506	757
15	*6*	2.9	6	11	22	32.3	59.7	91.7	153	289	487	732
15	*8*	2.5	5.2	9.7	19.5	28.9	53.8	83.2	140	268	455	689
15	*10*	2.3	4.7	8.8	17.8	26.3	49.3	76.7	130	250	429	683
15	*15*	1.9	3.9	7.3	14.8	22.1	41.7	65.3	112	218	379	583
15	*20*	1.6	3.4	6.4	13	19.4	36.8	57.9	99.4	196	344	532
15	*25*	1.5	3.1	5.7	11.7	17.5	33.3	52.5	90.5	179	316	492
15	*30*	1.3	2.8	5.3	10.7	16.1	30.7	48.4	83.6	166	295	460
15	*40*	1.2	2.4	4.6	9.4	14	26.8	42.4	73.5	147	262	411
15	*60*	1	2	3.8	7.7	11.6	22.1	35.1	61	123	220	347
15	*100*	0.7	1.5	2.9	6	9	17.3	27.5	47.9	96.8	175	276
15	*160*	0.6	1.2	2.3	4.7	7.1	13.7	21.8	38.1	77.3	140	222
15	*250*	0.5	1	1.9	3.8	5.7	11	17.5	30.6	62.3	113	179
Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
25	*2*	5.7	11.3	20	37.6	53.5	93.2	138	219	391	628	918
25	*3*	4.9	9.9	17.8	34	48.8	86.5	129	208	374	608	893
25	*4*	4.4	8.9	16.2	31.3	45.3	81	122	198	360	589	869
25	*5*	4	8.2	14.9	29.1	42.3	76.4	116	189	347	572	848
25	*6*	3.7	7.6	13.9	27.4	39.9	72.6	110	181	336	556	828
25	*8*	3.3	6.7	12.4	24.6	36.1	66.4	102	169	316	529	791
25	*10*	3	6.1	11.3	22.6	33.3	61.5	94.6	158	299	505	759
25	*15*	2.5	5.1	9.5	19.1	28.3	52.9	82.1	139	267	457	694
25	*20*	2.1	4.5	8.3	16.8	25	47.1	73.5	125	243	420	643
25	*25*	1.9	4	7.5	15.2	22.7	42.9	67.1	115	225	391	602
25	*30*	1.8	3.7	6.9	14	20.9	39.6	62.2	107	210	367	568
25	*40*	1.5	3.2	6	12.2	18.3	34.8	54.9	94.5	187	331	514
25	*60*	1.3	2.6	4.9	10.1	15.1	28.9	45.7	79.1	158	281	440
25	*100*	1	2	3.8	7.9	11.8	22.7	36	62.5	126	226	356
25	*160*	0.8	1.6	3.1	6.3	9.4	18.1	28.7	50	101	183	289
25	*250*	0.6	1.3	2.4	5	7.6	14.5	32.1	40.3	81.7	148	235

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	¾	1	1¼	1½	2	2½	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
50	*2*	7.6	14.7	25.4	46.5	65.3	112	163	256	451	718	1045
50	*3*	6.8	13.2	23.2	43.4	61.4	106	156	248	439	704	1027
50	*4*	6.1	12.2	21.6	40.8	58.1	102	150	240	429	691	1011
50	*5*	5.7	11.3	20.2	38.6	55.2	97.4	145	233	419	678	996
50	*6*	5.3	10.6	19.1	36.7	52.8	93.8	140	226	410	666	981
50	*8*	4.7	9.5	17.3	33.6	48.7	87.5	132	215	393	644	953
50	*10*	4.3	8.7	15.9	31.2	45.5	82.4	125	205	378	624	927
50	*15*	3.6	7.4	13.6	26.9	39.6	72.7	113	185	347	582	872
50	*20*	3.1	6.5	12	24	35.5	65.8	101	170	323	547	825
50	*25*	2.8	5.9	10.9	21.9	32.4	60.5	93.8	158	303	517	785
50	*30*	2.6	5.4	10	20.3	30.1	56.3	87.6	148	286	492	750
50	*40*	2.3	4.7	8.8	17.8	26.6	50.1	78.3	133	260	451	692
50	*60*	1.9	3.9	7.3	14.8	22.1	42	66	113	224	393	608
50	*100*	1.4	3	5.7	11.6	17.4	33.3	52.6	91	182	323	504
50	*160*	1.1	2.4	4.5	9.3	13.9	26.7	42.3	73	148	265	416
50	*250*	0.9	1.9	3.6	7.5	11.2	21.5	34.2	59	120	217	342
Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	¾	1	1¼	1½	2	2½	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
75	*2*	9.1	17.2	29.4	53.3	74.3	126	183	286	501	795	1154
75	*3*	8.2	15.8	27.3	50.4	70.7	121	177	279	491	783	1140
75	*4*	7.5	14.6	25.7	47.8	67.6	117	172	272	482	772	1127
75	*5*	7	13.7	24.3	45.7	64.8	113	167	266	474	762	1114
75	*6*	6.5	13	23.1	43.7	62.4	110	162	260	466	751	1101
75	*8*	5.9	11.8	21.1	40.6	58.3	103	154	249	450	732	1077
75	*10*	5.4	10.8	19.6	38	54.9	98.2	148	240	437	714	1054
75	*15*	4.5	9.2	16.9	33.2	48.4	88	134	220	407	675	1004
75	*20*	4	8.2	15.1	29.9	43.8	80.5	123	204	383	641	960
75	*25*	3.6	7.4	13.7	27.4	40.3	74.6	115	192	363	612	921
75	*30*	3.3	6.8	12.7	25.4	37.6	69.8	108	181	345	587	887
75	*40*	2.9	6	11.2	22.5	33.4	62.5	97.2	164	317	544	828
75	*60*	2.4	5	9.3	16.8	28	52.9	82.8	141	276	481	739
75	*100*	1.9	3.9	7.3	14.8	22.2	42.2	66.5	115	227	401	623
75	*160*	1.5	3.1	5.8	11.9	17.8	34	53.8	93	186	332	520
75	*250*	1.2	2.5	4.7	9.6	14.4	27.5	43.6	76	153	274	432

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
100	*2*	10.3	19.4	32.9	59.3	82.2	139	201	314	547	868	1258
100	*3*	9.4	17.9	30.9	56.4	78.9	134	195	307	539	857	1246
100	*4*	8.7	16.8	29.2	54	75.9	130	190	301	531	847	1234
100	*5*	8.1	15.8	27.8	51.8	73.2	127	186	295	523	837	1222
100	*6*	7.6	15	26.5	49.9	70.8	123	182	289	515	828	1210
100	*8*	6.9	13.7	24.5	46.6	66.6	117	174	279	501	810	1188
100	*10*	6.3	12.7	22.8	43.9	63.1	112	167	270	488	793	1167
100	*15*	5.4	10.9	19.9	38.7	56.3	101	153	250	459	756	1120
100	*20*	4.7	9.7	17.8	35.1	51.3	93.4	142	234	435	723	1077
100	*25*	4.3	8.8	16.3	32.3	47.4	87	133	221	415	694	1039
100	*30*	4	8.2	15.1	30.1	44.3	81.8	126	210	397	668	1005
100	*40*	3.5	7.2	13.3	26.7	39.5	73.7	114	192	367	625	946
100	*60*	2.9	5.9	11.1	22.4	33.4	62.7	97.9	166	323	558	853
100	*100*	2.2	4.7	8.7	17.8	26.6	50.4	79.2	136	268	471	728
100	*160*	1.8	3.7	7	14.3	21.4	40.7	64.3	111	222	393	614
100	*250*	1.4	3	5.6	11.5	17.3	33	52.3	91	182	326	513
Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
150	*2*	12.5	23.3	39.2	70.1	96.8	163	235	366	636	1006	1457
150	*3*	11.6	21.8	37.2	67.4	93.7	159	230	360	628	996	1446
150	*4*	10.8	20.6	35.5	64.9	90.8	155	225	354	621	987	1435
150	*5*	10.2	19.6	34	62.8	88.1	151	221	348	613	979	1425
150	*6*	9.6	18.7	32.7	60.8	85.7	148	217	343	606	970	1414
150	*8*	8.8	17.3	30.5	57.3	81.4	142	209	333	593	954	1394
150	*10*	8.1	16.1	28.7	54.4	77.7	137	202	324	581	938	1375
150	*15*	6.9	14	25.2	48.7	70.3	125	188	304	553	902	1330
150	*20*	6.2	12.5	22.8	44.5	64.6	117	176	288	529	870	1289
150	*25*	5.6	11.4	21	41.2	60.2	109	166	274	507	841	1251
150	*30*	5.2	10.6	19.5	38.6	56.5	103	158	261	488	815	1217
150	*40*	4.5	9.4	17.3	34.5	50.8	93.9	145	241	456	769	1156
150	*60*	3.8	7.8	14.5	29.2	43.3	80.8	125	212	407	696	1058
150	*100*	2.9	6.1	11.5	23.3	34.7	65.6	103	175	343	597	918
150	*160*	2.3	4.9	9.2	18.7	28	53.3	84	145	286	505	785
150	*250*	1.9	3.9	7.4	15.2	22.7	43.4	68.6	119	238	423	662

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
200	*2*	14.6	26.9	45	80.2	111	185	267	415	721	1139	1649
200	*3*	13.6	25.4	43.1	77.5	107	181	262	409	713	1130	1638
200	*4*	12.7	24.2	41.3	75.1	105	177	257	404	706	1121	1628
200	*5*	12	23.1	39.8	72.8	102	174	253	398	699	1113	1618
200	*6*	11.5	22.1	38.4	70.8	99.4	171	249	393	692	1105	1608
200	*8*	10.5	20.5	36	67.2	95	165	242	383	679	1089	1588
200	*10*	9.7	19.2	34	64.1	91.1	159	235	374	667	1073	1570
200	*15*	8.4	16.8	30.2	57.9	83.2	147	220	354	639	1038	1525
200	*20*	7.5	15.2	27.5	53.2	77	138	207	337	614	1005	1485
200	*25*	6.8	13.9	24.3	49.5	72	130	197	322	592	967	1447
200	*30*	6.3	12.9	23.6	46.5	67.9	123	188	309	572	949	1412
200	*40*	5.6	11.4	21.1	41.8	61.4	113	173	287	538	901	1349
200	*60*	4.6	9.6	17.7	35.5	52.5	97.7	151	254	484	823	1245
200	*100*	3.6	7.5	14.1	28.5	42.4	79.9	125	212	413	714	1094
200	*160*	2.9	6	11.3	23	34.4	65.2	103	176	347	610	944
200	*250*	2.3	4.9	9.1	18.6	27.9	53.3	84.1	145	290	514	802
Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
250	*2*	16.5	30.4	50.7	89.9	124	207	298	463	803	1268	1836
250	*3*	15.5	28.8	48.6	87.2	121	203	293	457	796	1260	1826
250	*4*	14.6	27.5	46.9	84.7	118	199	289	452	789	1251	1815
250	*5*	13.8	26.4	45.2	82.4	115	196	284	446	782	1243	1805
250	*6*	13.2	25.4	43.8	80.3	113	192	280	441	775	1234	1795
250	*8*	12.2	23.6	41.3	76.6	108	186	273	431	762	1219	1776
250	*10*	11.3	22.2	39.1	73.3	104	180	265	422	750	1203	1757
250	*15*	9.8	19.6	35	66.7	95.4	168	250	401	721	1167	1713
250	*20*	8.8	17.7	31.9	61.5	88.7	158	237	383	696	1135	1672
250	*25*	8	16.3	29.5	57.5	83.3	150	226	368	673	1104	1634
250	*30*	7.4	15.1	27.6	54.1	78.7	143	216	354	652	1076	1598
250	*40*	6.5	13.4	24.7	48.8	71.5	131	200	330	616	1026	1533
250	*60*	5.4	11.3	20.9	41.7	61.5	114	176	294	558	944	1423
250	*100*	4.3	8.9	16.6	33.6	49.9	93.7	146	248	479	826	1261
250	*160*	3.4	7.1	13.4	27.2	40.6	76.8	121	207	406	710	1096
250	*250*	2.7	5.8	10.8	22.1	33	62.9	99.2	171	340	602	937

Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
300	*2*	18.4	33.7	56.1	99.4	137	228	328	510	884	1395	2019
300	*3*	17.3	32.1	54	96	134	224	323	504	877	1386	2009
300	*4*	16.4	30.8	52.2	94.1	131	220	319	498	869	1378	1998
300	*5*	15.6	29.6	50.5	91.7	128	217	314	493	862	1369	1988
300	*6*	14.9	28.5	49	89.6	125	213	310	488	856	1361	1978
300	*8*	13.8	26.6	46.3	85.6	120	207	302	478	843	1345	1959
300	*10*	12.8	25.1	44.1	82.2	116	201	295	468	830	1330	1940
300	*15*	11.2	22.2	39.6	75.1	107	188	279	447	801	1293	1895
300	*20*	10	20.1	36.2	69.6	100	178	265	428	775	1260	1853
300	*25*	9.2	18.6	33.6	65.2	94.2	169	253	412	751	1229	1814
300	*30*	8.5	17.3	31.5	61.5	89.2	161	243	397	729	1200	1777
300	*40*	7.5	15.4	28.2	55.6	81.3	148	225	372	691	1148	1710
300	*60*	6.3	12.9	23.9	47.7	70.2	130	199	333	639	1061	1595
300	*100*	4.9	10.3	19.1	38.5	57.2	107	167	282	544	943	1422
300	*160*	3.9	8.2	15.4	31.3	46.6	88.1	138	236	463	807	1243
300	*250*	3.2	6.6	12.5	25.4	38	72.3	114	196	389	687	1068
Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
350	*2*	20.3	37	61.4	109	149	249	358	556	963	1519	2199
350	*3*	19.1	35.3	59.3	106	146	245	353	550	956	1510	2189
350	*4*	18.1	33.9	57.4	103	143	241	348	544	949	1502	2178
350	*5*	17.3	32.7	55.7	101	140	237	344	539	941	1493	2168
350	*6*	16.6	31.5	54.1	98.6	137	234	340	534	935	1484	2158
350	*8*	15.3	29.6	51.3	94.5	132	227	331	523	921	1468	2139
350	*10*	14.4	28	48.9	90.9	128	221	324	514	908	1452	2120
350	*15*	12.5	24.8	44.1	83.5	119	208	307	492	879	1414	2075
350	*20*	11.3	22.6	40.5	77.6	111	196	293	473	852	1379	2032
350	*25*	10.3	20.8	37.6	72.8	105	187	280	455	827	1347	1992
350	*30*	9.6	19.4	35.3	68.8	99	178	269	440	804	1317	1954
350	*40*	8.5	17.3	31.7	62.4	91	163	250	413	764	1262	1885
350	*60*	7.1	14.6	26.9	53.7	79	145	222	372	699	1170	1765
350	*100*	5.6	11.6	21.6	43.5	64	120	186	316	607	1034	1582
350	*160*	4.5	9.3	17.4	35.4	52	99	155	266	519	897	1390
350	*250*	3.6	7.5	14.1	28.8	43	81	128	222	438	766	1200

Set Pressure (psig)	**Length (ft)**	**Nominal Pipe Size, NPS, DN**										
		½	*¾*	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*4*	*5*	*6*
		15	20	25	32	40	50	65	80	100	125	150
400	*2*	22	40.2	66.6	118	162	270	387	601	1041	1642	2376
400	*3*	20.9	38.5	64.5	115	158	266	382	595	1034	1633	2366
400	*4*	19.8	37	62.5	122	155	262	378	589	1026	1625	2355
400	*5*	18.9	35.7	60.7	110	152	258	373	584	1019	1616	2345
400	*6*	18.2	34.5	59.1	107	150	254	369	578	1012	1608	2335
400	*8*	16.9	32.5	56.1	103	145	247	360	568	999	1591	2315
400	*10*	15.8	30.7	53.6	99.3	140	241	353	558	986	1575	2295
400	*15*	13.9	27.4	48.5	91.5	130	227	335	535	955	1537	2249
400	*20*	12.5	24.9	44.6	85.2	122	215	320	515	927	1502	2205
400	*25*	11.4	23	41.6	80.1	115	205	307	497	902	1469	2164
400	*30*	10.6	21.5	39	75.8	110	197	296	481	878	1438	2125
400	*40*	9.4	19.2	35.1	68.9	100	182	276	453	836	1382	2052
400	*60*	7.9	16.2	26.9	59.4	87.2	160	246	409	767	1286	1927
400	*100*	6.2	12.9	24	48.3	71.5	133	207	349	669	1143	1734
400	*160*	5	10.4	19.4	39.3	58.5	110	173	294	574	996	1529
400	*250*	4	8.4	15.7	32	47.9	90.9	143	246	468	854	1324

Appendix B (Normative)

Minimum Values of Design Pressure and Leak Test Pressure – NH_3

	Compressors		LP Side Components Including Vessels, Heat Exchangers, Evaporators, Pumps & Piping	Hot Gas Defrost Evaporators & Piping	HP Side Components Including Valves, Sensing Devices, Heat Exchangers, Condensers, Pumps & Piping	
	LP Side & Boosters	HP Side			Water-cooled Systems	Air-cooled Systems
psig	150	300	150	250	250	300
kPa gage	1030	2070	1030	1720	1720	2070

Appendix C (Informative)

Ammonia Characteristics and Properties

(These appendices are not part of this standard. They are merely informative and do not contain requirements necessary for conformance to the standard. They have not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process.)

C.1 Ammonia Characteristics

The term ammonia, as used in this standard, refers to the compound formed by combination of nitrogen and hydrogen, having the chemical formula NH_3. It is not to be confused with aqua ammonia, which is a solution of ammonia gas in water. Whenever the term ammonia appears in this standard, it means refrigerant-grade anhydrous ammonia.

Experience has shown that ammonia is difficult to ignite and, under normal conditions, is a very stable compound. It requires temperatures of 840-930°F [450-500°C][723.2-773.2K] to cause it to dissociate slightly at atmospheric pressure. The flammable limits at atmospheric pressure are 15.5% to 27% by volume of ammonia in air. An ammonia-air mixture in an iron flask does not ignite below 1204°F [651.1°C][925.3K].

Since ammonia is self-alarming, it serves as its own warning agent so that a person is not likely to voluntarily remain in concentrations which are hazardous.

C.2 Physical Properties of Ammonia

	English	**Common Metric**	**SI**
Molecular symbol	NH_3	NH_3	NH_3
Molecular weight	17.031 lb/ lb-mol	17.031 g/mol	17.031 g/mol
Boiling point at one atmosphere*	-27.99°F	-33.33°C	239.82K
Freezing point at one atmosphere*	-107.78°F	-77.66°C	195.5K
Critical temperature	269.99°F	132.22°C	405.37K
Critical pressure	1644 psig	115.6 kg/cm^2 (gage)	11.34 MPa (gage)
Latent heat at -28°F (-33°C)(240.15K) and one atmosphere	588.8 Btu/lb	327.1 cal/g	1.369 MJ/kg
Relative density of vapor compared to dry air at 32°F (0°C)(273.15K) and one atmosphere	0.5967	0.5967	0.5967
Vapor density at -28°F (-33°C)(240.15K) and one atmosphere	0.05554 lb/ft^3	0.8896 kg/m^3	0.8896 kg/m^3
Specific gravity of liquid at -28°F (-33°C)(240.15K) compared to water at 39.4°F (4.0°C) (277.1K)	0.6816	0.6816	0.6816
Liquid density at -28°F (-33°C)(240.15K) and one atmosphere*	42.55 lb/ft^3	681.6 kg/m^3	681.6 kg/m^3
Specific volume of vapor at 32°F (0°C)(273.15K) and one atmosphere*	20.80 ft^3/lb	1.299 m^3/kg	1.299 m^3/kg
Flammable limits by volume in air at atmospheric pressure	15.5% to 27%	15.5% to 27%	15.5% to 27%
Ignition temperature	1204°F	651.1°C	924.13K
Specific heat, gas at 59°F (15°C)(288.15K) and one atmosphere*			
At constant pressure (c_p)	0.5184 Btu/ lb°F	0.5184 cal/g°C	2.1706 kJ/ kg K
At constant volume (c_v)	0.3928 Btu/ lb°F	0.3928 cal/g°C	1.6444 kJ/ kg K
Ratio of specific heats k(c_p/c_v, also γ) at 50°F (15°C) (288.15K) and one atmosphere*	1.320	1.320	1.320

NOTE:

*One standard atmosphere = 14.696 psia [1.0333 kg/cm^2 absolute][101.33 kPa absolute]

Appendix D (Informative)

Duplicate Nameplates on Pressure Vessels

The ASME Boiler and Pressure Vessel Code [ref.4.1.1] permits duplicate (or secondary) nameplates on pressure vessels. Duplicate nameplates may be desirable in certain circumstances, especially where the original nameplate may be obscured by insulation.

Experience has shown that attempting to access the original nameplate for inspection through windows, removable insulation sections, stanchion mounting, etc. tends to compromise the integrity of the insulation system. Moisture ingress into the insulation system follows, with possible damage to the pressure vessel. The use of duplicate nameplates helps prevent vessel damage from inspection ports and other deliberate damage to insulation.

Unfortunately, using duplicate nameplates creates the possibility that the wrong (duplicate) nameplate will be applied to a vessel. The ASME Boiler and Pressure Vessel Code [ref.4.1.1] specifies that the vessel manufacturer must ensure that the duplicate nameplate is properly applied. While the easiest way to accomplish this is for the manufacturer to weld the nameplate to a support or other permanent vessel appurtenance that will not be insulated, field installation is also permitted. (Some inspection authorities consider the insulation jacket as a permanent attachment to the vessel, and therefore the duplicate nameplate may be applied to the jacket.) The manufacturer's procedures for ensuring a proper match of duplicate to original must be rigorously followed. It is advisable to record the location of the original nameplate should inspection be necessary.

Various inspection authorities such as State vessel inspectors may demand to inspect and/or approve the duplicate and original nameplates before insulation is applied. While many inspection bodies will accept a duplicate nameplate as evidence of ASME Boiler and Pressure Vessel Code [ref.4.1.1] compliance for an insulated vessel, authorized inspectors may always demand to inspect the original vessel, including its nameplate. In particular, when the inspector is concerned about the physical condition of the vessel or questions the provenance of the duplicate nameplate, he or she may require the entire insulation system or any part to be removed to permit inspection. Damage to the insulation system must be promptly and professionally repaired, and due allowance should be made for the shorter service life of the repaired insulation system.

Appendix E (Informative)

Method for Calculating Discharge Capacity of Positive Displacement Compressor Pressure Relief Device

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The following calculation method provides the required discharge capacity of the compressor pressure relief device in 6.1.2.1.

$$W_r = \frac{Q \cdot PL \cdot \eta_v}{v_g} \qquad \text{(E.1)}$$

where

W_r = mass flow of refrigerant, lb_m/min [kg/s]

Q = swept volume flow rate of compressor, ft^3/min [m^3/s]

PL = fraction of compressor capacity at minimum regulated flow

η_v = volumetric efficiency (assume 0.9 unless actual volumetric efficiency at relieving pressure is known)

v_g = specific volume of refrigerant vapor (rated at 50°F [10°C] saturated suction temperature), ft^3/lb_m [m^3/kg]

Next, find the relieving capacity in mass flow of air, W_a, for an ASME-rated [ref.4.1.1] pressure relief device:

$$W_a = W_r r_w \qquad \text{(E.2)}$$

$$r_w = \frac{c_a}{c_r}\sqrt{\frac{T_r}{T_a}}\sqrt{\frac{M_a}{M_r}} \qquad \text{(E.3)}$$

where

r_w = refrigerant-to-standard-air-mass-flow conversion factor

M_r = molar mass of refrigerant (17.0 for ammonia)

M_a = molar mass of air = 28.97

T_a = absolute temperature of the air = 520 R (289 K)

c_a = constant for air = 356

c_r = constant for refrigerant (as determined from Equation E.4)

T_r = absolute temperature of refrigerant = 510 R (283 K)

$$c_r = 520\sqrt{k\left[\frac{2}{k+1}\right]^{\frac{k+1}{k-1}}} \qquad \text{(E.4)}$$

where

k = ratio of specific heats c_p/c_v

c_p = constant-pressure specific heat of refrigerant at a refrigerant quality of 1 at 50°F (10°C).

c_v = constant-volume specific heat of refrigerant at a refrigerant quality of 1 at 50°F (10°C).

Constants for ammonia are listed below:

k = 1.422

M_r = 17.0

c_r = 358.0

r_w = 1.28

EXAMPLE:
Determine the flow capacity of a relief device for an ammonia (R-717) screw compressor with a swept volume, Q, of 1665 ft^3/min (0.7858 m^3/s). The compressor is equipped with capacity control that is actuated at 90% of the pressure relief device set pressure to its minimum regulated flow of 10%.

Q = 1665 ft^3/min (0.7858 m^3/s)

η_v = 0.90 (assumed)

PL = 0.1

v_g = 3.2997 ft^3/lb_m (0.206 m^3/kg)

$$W_r = \frac{1665\frac{ft^3}{\text{min}} \bullet 0.1 \bullet 0.9}{3.2997\frac{ft^3}{lb_m}} = 45.4\frac{lb_m}{\text{min}}$$

$$\left[\; W_r = \frac{0.7858\frac{m^3}{s} \bullet 0.1 \bullet 0.9}{0.206\ \frac{m^3}{kg}} = 0.343\frac{kg}{\text{s}} \;\right]$$

$$W_a = W_r \bullet r_w = 45.4 \bullet 1.28 = 58.1\frac{lb_m}{\text{min}} \text{ of air}$$

$$\left[\; W_a = W_r \bullet r_w = 0.343 \bullet 1.28 = 0.439\frac{kg}{s} \text{ air} \;\right]$$

Converting to standard cubic feet/minute (SCFM), where V_a= specific volume of air = 13.1 ft^3/lb_m (0.818 m^3/kg) for dry air at 60°F (15.6°C),

SCFM = 13.1(58.1) = 761 ft^3/min

[SCFM = 0.818(0.439) = 0.359 m^3/s].

Appendix F (Informative)

Pipe Hanger Spacing, Hanger Rod Sizing, and Loading

F.1 Recommended maximum spacing of hangers and minimum hanger rod size for steel pipe, adapted from MSS SP-69 [ref.4.2.5] is shown below. Spacing does not apply where span calculations are made or where concentrated loads such as flanges, valves, specialties, etc. are placed between supports.

Table F.1

Nominal Pipe Size (in)	Maximum Span (ft)	Minimum Rod Diameter (in)
Up to 1	7	⅜
1¼ –1½	9	⅜
2	10	⅜
2½	10	½
3	12	½
4	14	⅝
5	16	⅝
6	17	¾
8	19	⅞
10	22	⅞
12	23	⅞
14	25	1
16	27	1
18	28	1¼
20	30	1¼

F.2 The maximum recommended hanger rod loading based on threaded hot rolled steel conforming to ASTM A 575-96 [ref.4.1.3.14] is shown.

Table F.2

Rod Diameter (in)	Maximum Load (lb)	Rod Diameter (in)	Maximum Load (lb)
⅜	610	1½	11 630
½	1 130	1¾	15 700
⅝	1 810	2	20 700
¾	2 710	2¼	27 200
⅞	3 770	2½	33 500
1	4 960	2¾	41 600
1⅛	6 230	3	50 600
1¼	8 000	3¼	60 500

Adapted from MSS SP-69 [ref.4.2.5].

Appendix G (Informative)

Hydrostatic Pressure Relief

NOTE:
This Appendix is presented entirely in the English engineering unit system.

G.1 Background

Hydrostatic pressures can occur when liquids become confined within enclosed volumes with no gases present. For this to occur, the temperatures of such liquids must be below their boiling points.

Liquids such as oil, secondary refrigerants, and subcooled primary refrigerants can become entrapped when certain components of a closed-circuit ammonia refrigerating system are isolated from other parts of the system by valves or other means. If there is an increase in temperature in such confined liquids, rapidly rising pressures can occur that are functions of the bulk moduli of elasticity of the liquids. While such increases in temperature and pressure can be very rapid, the corresponding rates of volume increase of the liquids are relatively low. Therefore, relief devices installed to relieve the resulting pressure need not have the flow capacity of vapor relief devices.

Practitioners have found that very small relief devices satisfy most requirements for hydrostatic relief found in refrigeration service. The technical literature available that quantifies such requirements, based on empirical test data, is found almost exclusively in areas of practice that are much more severe than refrigeration service. However, many authorities having jurisdiction require calculations or other evidence to justify selection and sizing of hydrostatic relief devices. In those cases, it is acceptable good engineering practice to demonstrate that a relief device having adequate capacity for an extremely severe application will certainly be adequate for less severe circumstances typically encountered in refrigeration applications. To that end, applicable methodology borrowed from more severe applications such as those found in the oil and gas industries provide a safe and conservative basis for hydrostatic relief protection in refrigeration applications. The objective is to provide adequate relief, not necessarily to determine exactly how much liquid expansion will occur. In most, if not all cases, the smallest relief valves manufactured for such purposes will have greater flow capacities than the requirements found by calculation for extremely severe circumstances.

API Practice 520 [ref.4.2.4] addresses the sizing of orifices needed to relieve hydrostatic pressure as defined above. This standard contains an equation for determining the areas of such orifices as stated below:

$$A = \frac{Q}{38K_dK_wK_v}\sqrt{\frac{G}{P_1 - P_2}}$$

where

A = required effective discharge area, in square inches

Q = flow rate, in US gallons per minute

K_d = effective coefficient of discharge (0.65 for hydrostatic relief purposes)

K_w = correction factor due to back pressure (1.0 if back pressure is atmosphere or valve responds only to pressure differential across its seat)

K_v = correction factor due to viscosity

G = specific gravity of the liquid at the flowing temperature

P_1 = upstream relieving pressure in psig

P_2 = total back pressure in psig (zero for discharge to atmosphere)

Q is determined by the relation:

$$Q = \frac{BH}{500GC}$$

where

B = cubical expansion coefficient per degree Fahrenheit for the liquid at the expected temperature

H = total heat of absorption to the wetted bare surface of a vessel, pipe or container in BTU per hour

($H = 21{,}000\ A^{0.82}$, where A = total wetted surface in square feet)

G = specific gravity of the liquid at the flowing temperature

C = specific heat of the trapped fluid in BTU per lb-°F

K_v is determined as follows:

Refer to Figure G1 below to find K_v as a function of the Reynolds number (R), which is defined by the following equation:

$$R = \frac{12{,}700Q}{U\sqrt{A}}$$

where

Q = flow rate at the flowing temperature in US GPM

U = viscosity at the flowing temperature in Saybolt Universal Seconds

A = effective discharge area, in square inches (from manufacturers' standard orifice areas)

Figure G1: Capacity Correction Factor K Due to Viscosity

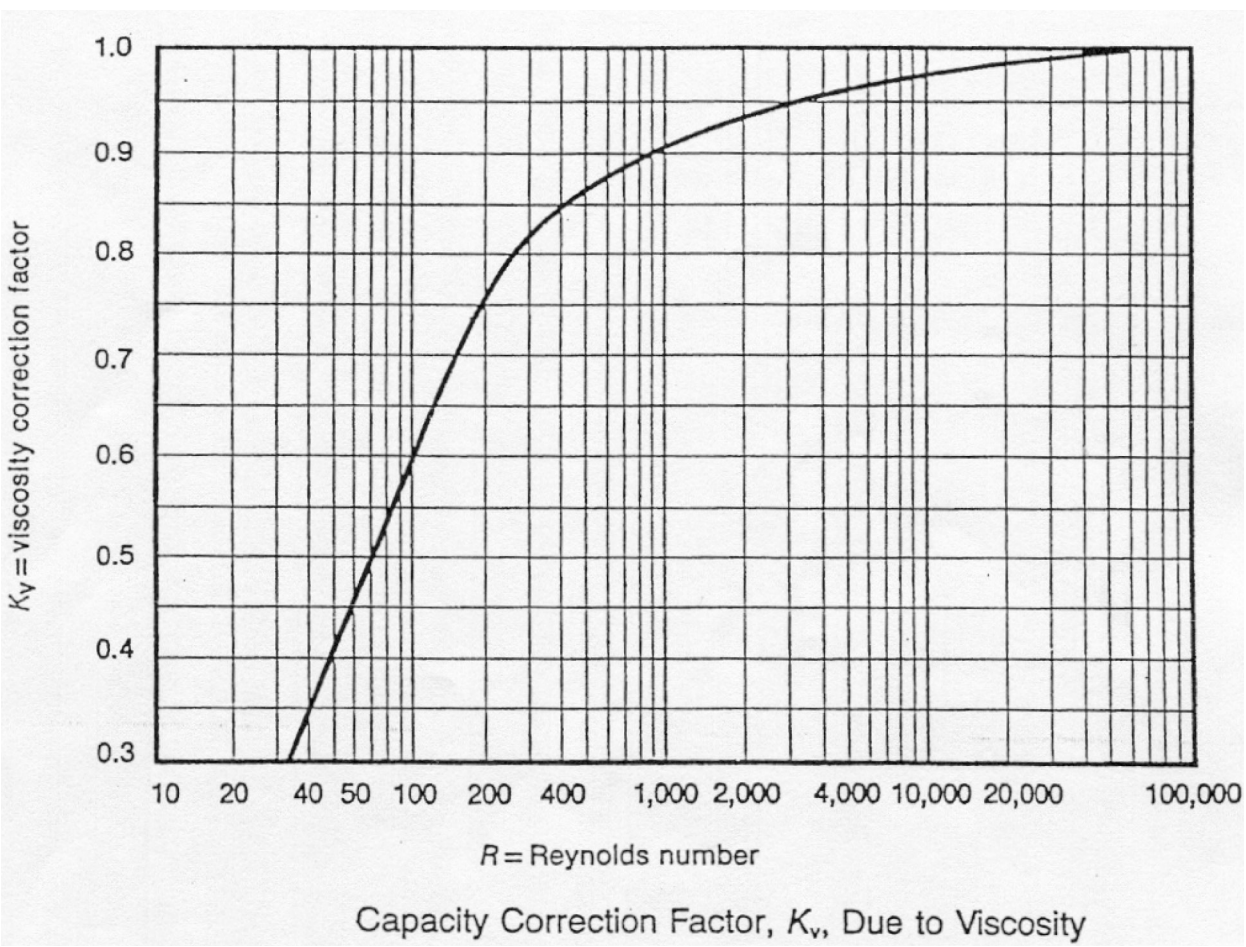


Figure G1 was reprinted by permission from Oil and Gas Journal, November 20, 1978 edition. Copyright 1978, Oil and Gas Journal. http://ogj.pennnet.com/home.cfm.

G.2 Hydrostatic Pressure Relief of ASME Pressure Vessels

This section pertains to vessels covered by Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code [ref.4.1.1], herein referred to as *ASME pressure vessels*.

When ASME pressure vessels contain liquid refrigerant and can be isolated from the other parts of a closed-circuit ammonia refrigerating system, the rules of Section 11 apply. However, when ASME pressure vessels contain a non-boiling liquid (i.e., a liquid whose vapor pressure at maximum normal operational, maintenance or standby conditions is less than the relief valve setting), specific requirements of the ASME Boiler and Pressure Vessel Code [ref.4.1.1] for hydrostatic relief valves apply:

a. Hydrostatic relief valves protecting ASME pressure vessels must bear an ASME UV Code Symbol Stamp. (Code Case BC94-620)

b. Hydrostatic relief valves protecting ASME pressure vessels must be certified and rated for liquid flow. (Code Case BC94-620)

c. Any liquid pressure relief valve used shall be at least NPS 1/2. (UG-128)

d. The opening through all pipe, fittings, and nonreclosing pressure relief devices (if installed) between a pressure vessel and its pressure relief valve shall have at least the area of the pressure relief valve inlet. In this upstream system, the pressure drop shall not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve. (UG-135 (b) (1))

e. The size of the discharge lines leaving a hydrostatic relief valve shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief valve below that required to properly protect the vessel. (UG-135 (f))

f. The hydrostatic relief valve shall be capable of preventing the pressure from rising more than 10% above the maximum allowable working pressure during normal service or standby conditions.

G.3 Sample calculations

To illustrate how to apply these concepts and requirements, two examples of sizing hydrostatic relief valves for pressure-containing components are provided below.

NOTE:
These examples are for oil in the oilside of oil coolers rather than ammonia on the refrigerant side.

EXAMPLE 1: Sizing a Hydrostatic Relief Valve for an ASME Pressure Vessel

Determine the hydrostatic relief valve required to protect an oil cooler of diameter 10" and length 12 ft with MAWP 400 psig.

Assume that the oil temperature is 100°F and that the oil viscosity (U) is 300 Saybolt Universal Seconds at 100°F. From the oil manufacturer's data, the cubical expansion coefficient (B) is 0.00043/°F, specific gravity (G) is 0.87 and specific heat (C) is 0.5.

First, determine the bare wetted external area (A) of the oil cooler, in square feet:

$$A = \pi dl = \pi \frac{10.75}{12} \times 12 = 33.8 \text{ ft}^2$$

Next, determine total heat absorption (H) of the wetted bare surface of the oil cooler when exposed to maximum normal conditions:

$$H = 21{,}000\ A^{0.82}$$

$$H = 21{,}000 \times (33.8)^{0.82} = 376{,}644 \text{ Btu/Hr.}$$

Next, determine rate of increase of the oil volume from the relation below:

$$Q = \frac{BH}{500GC}$$

$$Q = \frac{0.00043 \times 376{,}644}{500 \times 0.87 \times 0.5} = 0.74 \text{ gpm}$$

Assume the relief valve will discharge into

another part of the system having relief protection set at 300 psig. To prevent the pressure in the oil cooler from exceeding 400 psig under all conditions, the hydrostatic relief valve must be selected for 100 psi differential.

A liquid-rated ASME certified relief valve is commercially available with 1/2" NPT inlet and 3/4" NPT outlet. The valve's capacity at 100 psi pressure differential is 25.9 gal per min, 35 times the oil volume rate of increase. The valve therefore meets all ASME requirements. Per the ASME code, total inlet and outlet pressure losses may total 40 psi and still meet code requirements.

EXAMPLE 2: Sizing a Hydrostatic Relief Valve for a non-ASME component

Determine the orifice area required to protect an oil cooler with diameter 5" and length 12 feet with MAWP 400 psig.

Assume that the oil temperature is 100°F and oil viscosity (U) is 300 Saybolt Universal Seconds at 100°F. From the oil manufacturer's data, the cubical expansion coefficient (B) is 0.00043/°F, specific gravity (G) is 0.87 and specific heat (C) is 0.5.

First, determine the bare wetted external area of the oil cooler, in square feet:

$$A = \pi dl = \pi \frac{5.563}{12} \times 12 = 17.48 \text{ ft}^2$$

Next, determine total heat absorption of the wetted bare surface of the oil cooler when exposed to maximum normal conditions from the relation:

$H = 21{,}000\ A^{0.82}$, outlined above.

$H = 21{,}000 \times (17.48)^{0.82} = 219{,}298$ Btu/hr.

Next, determine rate of increase of the oil volume from the relation:

$$Q = \frac{BH}{500GC}$$

$$Q = \frac{0.00043 \times 219{,}298}{500 \times 0.87 \times 0.5} = 0.433 \text{ gpm}$$

Next, determine the viscosity correction factor (K_v) from Figure G1 and the Reynolds number (R) from the formula below:

$$R = \frac{12{,}700Q}{U\sqrt{A}}$$

To calculate R in this equation requires a value for A, which represents the orifice area. Interestingly, to calculate A using the primary equation requires a value for R. To solve this problem, an iterative method (trial and error) must be used. First, an approximate starting value of A must be estimated to obtain an initial estimate of R, which can then be used in the primary equation to calculate a new value for A. Comparing this calculated value of A to the initial approximation for A will enable a even better approximation for A for the next iteration. This iterative process will converge on a calculated value for A that is reasonably close to the final approximation for A. If it does not, more sophisticated mathematical methods are required to solve the equations.

Try a 1/16" orifice having an area of 0.003068 in^2.

$$R = \frac{12{,}700 \times 0.433}{300\sqrt{0.003068}} = 331$$

From Figure G1, $K_v = 0.825$

$$A = \frac{Q}{38K_dK_wK_v}\sqrt{\frac{G}{P_1 - P_2}}$$

Assume the pressure differential to another part of the system (P_1-P_2) is 100 psi.

$$A = \frac{0.433}{38 \times 0.65 \times 1 \times 0.825}\sqrt{\frac{0.87}{100}} = 0.00198 \text{ in}^2$$

The required flow area is much smaller (0.00198 in^2) than the area assumed in estimating the Reynolds number (0.003068 in^2). Therefore, a relief valve having a 1/16" diameter orifice is more than adequate.

For a second iteration, assume a 3/64" orifice with 0.0017 in^2 cross-sectional area. R would then become

$$R = \frac{12{,}700 \times 0.433}{300\sqrt{0.0017}} = 445$$

$$K_v = 0.85$$

$$A = \frac{0.433}{38 \times 0.65 \times 1 \times 0.85}\sqrt{\frac{0.87}{100}} = 0.00192\ in^2$$

This area requirement is approximately 13% greater than that of the 3/64" orifice. Therefore, we can conclude that an orifice between a diameter of 1/16" and 3/64" would be ideal. A 1/16" orifice will be more than adequate.

G.4 Inlet and Outlet Piping

The ASME Boiler and Pressure Vessel (B & PV) Code [ref.4.1.1] requires that hydrostatic relief valve inlet piping for ASME pressure vessels must have at least the area of the pressure relief valve inlet. Since the same code requires a minimum NPS 1/2" valve, the minimum inlet piping is established. Inlet piping requirements on larger hydrostatic relief valves would follow suit.

On outlet piping, the B & PV Code simply requires that the relief valve discharge lines are large enough to avoid reducing the relieving capacity of the pressure relief device below that required to properly protect the vessel. For normal over-pressure protection, ASME permits overpressurization of a vessel to 10% above its MAWP.

In the previous examples, the flows of liquid created by thermal expansion were very low. Consequently, outlet piping from commercially available certified ASME liquid relief valves could usually be much smaller than the nominal outlets of the valves themselves. For instance, consider the ASME vessel example with a 0.74 gpm relief requirement. The relief valve suggested for this application has a 3/4" NPT connection on the outlet. If, for example, the discharge piping is reduced to 1/2" in stainless steel tubing, the Reynolds number for oil having a nominal viscosity of 68 centistokes at 100° F is less than 60 (57.9). In laminar flow, which by definition is flow at or below Reynolds numbers of 2000, pressure loss to friction in psi per 100 ft of smooth pipe is given as:

$$h_f = \frac{43.3 V^2 G}{RD}$$

where

V = fluid velocity in ft/sec

G = specific gravity of fluid

R = Reynolds Number of fluid

D = I.D. of pipe in ft

From the previous example, oil flow due to thermal expansion is 0.74 gpm or 0.1 cfm. The 1/2" stainless steel tubing has a cross-sectional flow area of 1.0085×10^{-3} ft^2. Fluid velocity is therefore:

$$V = \frac{cfm}{60A}\ \text{ft/sec} = \frac{0.1}{60 \times 1.0085 \times 10^{-3}} = 1.65\ \text{ft/sec}$$

Discharge piping pressure drop through the 1/2" stainless tubing would therefore be:

$$h_f = \frac{43.3 V^2 G}{RD} = \frac{43.3 \times 1.65^2 \times 0.867}{57.9 \times 0.0358} = 49.3\ \text{psi/100 ft}$$

For a typical relief valve discharge pipe run of 6 ft, pressure drop due to friction would be less than 3 psi. Because ASME permits overpressurization of 10% above the MAWP of a pressure vessel, inlet and outlet losses could total 40 psi and meet ASME requirements. Therefore, hydrostatic relief valve outlet piping can be greatly reduced below the nominal outlet size of the relief valve selected in many cases.

Inlet and outlet piping for hydrostatic relief valves protecting non-ASME components containing incompressible non-refrigerants can be sized using identical techniques. In providing hydrostatic protection against ambient warming, 10% overpressurization above MAWP is permitted, providing the relief valve is selected at MAWP.

Hydrostatic relief devices may be located anywhere on the protected component. When used to protect an ASME vessel, they must bear a UV Code Symbol. When used to protect a non-ASME component, they must be listed by an approved nationally recognized testing laboratory or bear a UV Code Symbol.

Appendix H (Informative)

Insulation for Refrigeration Systems

Chapter 7 of the IIAR Piping Handbook [ref.4.2.2.3] covers insulation systems operating on below-ambient temperature piping systems ranging from +50°F to –100°F for piping, fittings, valves, vessels, equipment and heat exchangers typically used in industrial refrigeration systems.

H.1 Purpose

The purpose of the insulation system is to conserve energy by preventing heat infiltration, preventing condensation or ice formation, and minimizing corrosion.

The success of an insulation system for cold piping depends upon four factors: proper pipe preparation, correct refrigeration and insulation system design, adequate insulation thickness, and proper installation of the insulation and related materials such as vapor retarders, sealants, and protective jacketing. It is critical to maintain the integrity of the vapor retarder system. The insulating system must be regularly maintained and inspected after installation.

H.2 Fundamentals of Insulation

Heat is a form of energy, always moving from a higher to a lower temperature.

There are three types of heat transfer: conduction, through direct thermal contact between a hotter and a colder material, convection, through natural or forced circulation of a fluid, and radiation, through exchange of the infrared energy naturally given off by every object. Poor heat conductors are good insulation products. Water is a good conductor of heat. Water and water vapor are the prime enemy of an insulation system.

H.3 Design Considerations

When designing thermal insulation for a refrigeration system, consider thermal and mechanical factors, as well as process control issues.

In general, provide sufficient insulation to maintain an 8–10 BTU/hr heat gain per square foot of pipe surface. Recommended thickness tables can be found in Chapter 7 of the IIAR Piping Handbook [ref.4.2.2.3].

H.4 Effect of Water/Ice/Moisture on Insulation Value

Refrigerant systems are insulated to conserve energy and prevent surface condensation or "sweating."

When high absorption/permeability materials are used on these systems and the vapor retarder system fails, water vapor will move into the insulation condensing and eventually saturating the insulation material. This problem is more severe at lower system temperatures and when the system operates continuously in the cold mode. As more water vapor is absorbed, the thermal conductivity of the insulation material increases, lowering the surface temperature of the pipe.

Lower surface temperatures lead to more condensation which may eventually lead to insulation system freeze-up, frost-ups and total failure of the insulation material due to ice formation and water expansion, as well as corrosion of metal components.

H.5 Insulation Material Selection

Choose insulation material for suitability at both minimum and maximum system operating temperatures.

The manufacturer generally specifies the intended operating temperature ranges for an insulation material, based on thermal properties in that temperature range.

H.6 Corrosion Concerns

Piping systems corrode not because they are insulated, but because they are in contact with aerated water and/or a water-borne corrosive chemical.

Corrosion can occur under all types of insulation. Corrosion is caused by moisture ingress as a result of improper vapor retarder selection, installation, or maintenance, or mechanical abuse, or of voids in the insulation system that retain water.

Equipment or piping operating either steadily or cyclically at or above freezing (such as hot gas defrost systems) may experience significant corrosion problems. Pipe legs or instruments protruding into ambient-temperature areas may corrode faster than cold, insulated pipe mains.

Some areas of a piping system are more susceptible to corrosion than others. Where the risk of corrosion is elevated, apply a primer-paint coating system. The higher-risk areas include (but are not limited to) all pipe welds, control valve groups, areas around pump bases or control columns, evaporator coil headers, oil pots, valves, unions and flanges or any termination of insulation.

H.7 Insulation System Components

Many low temperature insulation products may perform reliably with proper installation and application of accessory materials.

The insulation itself should be a low thermal conductivity material with low water vapor permeability and it should provide moisture resistance. The types of insulation commonly used in industrial refrigeration are: *extruded polystyrene* insulation, *cellular glass*, *polyisocyanurate* insulation (The terms *polyisocyanurate* (PIR) and *polyurethane* (PU) are frequently used interchangeably. The two products use the same raw materials, in different ratios) and *closed-cell phenolic*.

Use a joint sealant on all insulations operating at below-ambient conditions. The sealant should be resistant to liquid water and to water vapor and be able to bond to the specific insulation surface. Use low-permeance insulation materials and a continuous, effective vapor retarder system.

Jacketing on insulated refrigeration piping protects the insulation and vapor retarder from damage.

Use protective jacketing. Seal all lap joints with appropriate weather barrier sealant.

H.8 Recommended Practices for Insulation Applications

Chapter 7 of the IIAR Piping Handbook [ref.4.2.2.3] covers recommended specifications and design features for typical refrigeration insulation applications. Also check State and local building codes for requirements.

Store insulation in a cool, dry location and protect it from the weather before and during application. Install vapor retarders and weather barriers over dry insulation.

Finish all welding and other hot work, as well as all pressure testing, before installing pipe insulation. The surfaces to be insulated should be free from all oil, grease, loose scale, rust and foreign matter and must be dry and free from frost. Complete site touch-up of shop coating (including preparation and painting at field welds) before insulating. For insulation and insulation accessories, use specific manufacturer instructions.

Appendix I (Informative)

Purging

A noncondensible gas separator (purger) separates, collects, and removes air and other gases from the closed-circuit ammonia refrigerating system. It is useful in most refrigeration plants.

Noncondensibles occur in systems from many causes. In systems operating below atmospheric pressure, air may be drawn through leaking packing, gaskets, rotary seals, or piping. Air can be introduced by improper charging or draining of ammonia or oil. In all systems, noncondensibles may remain after an inadequate evacuation of pressure test gas. Air may be introduced when the system has been opened for service or repair. Also, noncondensibles can occur from the breakdown of ammonia into nitrogen and hydrogen or water, or through the breakdown of oil into hydrocarbon gases and other salts, acids and sludge.

The result of noncondensible gases in the system is an increase in discharge pressure above normal. Higher discharge pressures cause a loss of system capacity concurrent with an increase in operating energy costs.

In the absence of automatic purgers, manual purging can be done by opening purge valves on tops of receivers or condensers unless prohibited by governing regulations. Purging can be accomplished during operation, but is likely to be more effective when the system is shut down. Since noncondensibles diffuse homogeneously with ammonia vapor, manual purging must be repeated several times to be effective. A more effective purging method is to nearly fill the component being purged with liquid ammonia, thus delivering the mixture of noncondensibles and ammonia vapor to the vicinity of the purge connection.

See the ASHRAE Refrigeration Handbook [ref.4.2.6] for additional information.

Appendix J (Informative)

Stress Corrosion Cracking

J.1 Background

Stress corrosion cracking (SCC) is a generic term describing the initiation and propagation of cracks that can occur in metals when subjected to stress in the presence of an enabling chemical environment. The stress can originate from an externally applied force, thermal stress, or residual stress from welding or forming.

J.2 Carbon steel is susceptible to SCC when stressed in the presence of ammonia and oxygen. Ammonia SCC has been recognized as a problem in the agricultural, chemical, and transport industries for many years. Studies have shown that the following factors contribute to the likelihood of SCC:

- Material yield strength greater than 50 ksi
- Oxygen contamination
- Residual or applied stress
- Water content less than 0.2%

J.3 SCC in Ammonia Refrigeration Systems

SCC in ammonia refrigeration systems is less common, but there have been reports of SCC in vessels and piping. Vessels seem to be more susceptible to SCC because of their higher material yield strengths and residual fabrication stresses. High pressure receivers are particularly vulnerable due to their potential for higher oxygen content (noncondensibles) and lower water content but SCC has also been found in low pressure vessels and piping.

Propagation of cracks via SCC is usually a gradual process. In ammonia refrigeration applications using carbon steel materials, stress corrosion cracks typically propagate from surface or subsurface discontinuities at the interior wall of a susceptible vessel or pipe. Sufficiently high stresses can propagate crack(s) through the material to emerge as a "pinhole leak" on the external surface. Discovery of a "pinhole leak" on a vessel is indicative of SCC and it is likely that additional cracks will be present in the same vessel. Repair of stress corrosion cracks is difficult and often not cost-effective.

J.4 Recommendations to Inhibit SCC in Ammonia Refrigeration Systems

The following recommendations are intended to minimize the likelihood of SCC for vessels constructed from carbon steel for use in ammonia refrigeration systems.

- The presence of noncondensible gases (specifically, oxygen) increases the probability of SCC. As such, purging of air from the system during both initial start-up and during operation and maintenance is important. At initial start-up and during commissioning, refer to evacuation recommendations in Section 5.5 of IIAR Bulletin 110. During refrigeration system operation, refer to air purging recommendations in Appendix I.
- Post-weld heat treat (PWHT) all high temperature vessels, especially vessels such as receivers, water chillers, intercoolers and economizers, to relieve the residual stress of welding and forming. Where low temperature vessels are critical to the process, or may be held at temperatures above 23°F (-5°C) for long periods of time, consideration should be given to PWHT.

EXCEPTIONS:

a. compressor oil separators
b. specialized vessels, such as plate heat exchangers, containing internal components that could be damaged, e.g. internal bushings, gaskets.

NOTE: PWHT may produce significant scale, which could cause operating problems in the system.

J.5 Refrigerant-grade anhydrous ammonia should meet or exceed the requirements of Federal Specification 0-A-445C, *Ammonia, Technical* [ref. 4.2.1].

Appendix K (Informative)

Emergency Pressure Control Systems

Emergency Pressure Control System Design and Installation Guidelines

K.1 General

K.1.1 Purpose. This technical guideline describes requirements for Emergency Pressure Control Systems (EPCS), which provide a means of internally mitigating an overpressure event in a refrigeration system that is independent of other required safety features and functions prior to operation of a pressure relief device.

K.1.2 Scope. Emergency Pressure Control Systems used as a means to mitigate an overpressure event involving an ammonia refrigeration system should comply with this technical guideline.

K.1.3 Limitations. An EPCS does not reduce or eliminate requirements for pressure relief devices set forth in other codes and standards.

K.2 Definitions

crossover valve is a valve that allows interconnection of two different portions of a refrigeration system that normally operate at different pressures.

emergency pressure control system (EPCS) is a system consisting of pressure sensors, independent compressor cut-off controls and automatically controlled crossover valves that will permit a high-pressure portion of a system to connect to a lower pressure portion of a system when opened.

header is a pipe to which other pipes or tubes are connected.

high side consists of those parts of a mechanical refrigerating system that are subjected to approximate condenser pressure.

low side consists of those parts of a mechanical refrigerating system that are subjected to approximate evaporator pressure.

pressure sensor is a mechanical or electronic device that measures ammonia pressure.

seep is a nuisance loss of refrigerant from a relief valve that can occur when the vessel pressure approaches the relief pressure setting, or a nuisance loss of refrigerant from a relief valve that can occur after the valve discharges if the valve does not fully re-seat.

zone is a general term used to identify a pressure level or temperature level of a refrigeration system. A zone will be associated with a compressor or group of compressors and the associated vessels serving a common pressure level. The term does not pertain to individual temperature controlled areas or rooms served by one or more compressor.

K.3 Referenced Standards

K.3.1 ANSI/ASHRAE Standard 15-2007

K.4 EPCS Recommended. Each zone should be provided with an EPCS. Each EPCS, other than the lowest pressure zone, should include a crossover valve to allow an abnormally high pressure to be discharged to a lower pressure zone.

K.4.1 Design and Installation Recommendations

K.4.2 Crossover Valve Connections.

K.4.2.1 Crossover valves should be connected to locations that will allow pressure in each high pressure zone to discharge to a lower pressure zone. Connections between pressure zones should continue in the above-described manner until all major pressure zones in a system are connected with the EPCS, always with

the intended flow traveling from a high pressure to a lower pressure.

K.4.2.2 Where multiple low-pressure zones are present, low-pressure zones with the highest pressure should be connected to the next lowest pressure zone.

K.4.2.3 Crossover valve connections should not be to pipes or tubes conveying liquid refrigerant.

K.4.2.4 High pressure crossover valve connections should come from the top of a dry suction header, compressor discharge header or other main gas header.

K.4.2.5 Low pressure crossover valve connections should discharge to the vapor space in a receiving vessel or to a common vapor header serving multiple receiving vessels.

K.4.2.6 The designer of a refrigeration system should consider the ability of the low pressure portion of the system to receive the high pressure discharge from the EPCS crossover valve. Operation of the crossover valve should not cause a release of refrigerant from pressure relief devices on the low pressure portion of the system.

K.4.2.7 Crossover valves and connecting piping and valves should have an internal diameter of not less than 1-inch.

K.4.2.8 Piping and tubing associated with a crossover valve should be independent of any other connections. The connection should not be in the same pipe or tube where a pressure relief device is connected.

K.4.3 Crossover Valve Type. The crossover valve should be of a type that fully opens when activated.

K.4.4 Isolation Valves

K.4.4.1 Each crossover valve should be provided with a stop valve on either side to allow isolation of the crossover valve for maintenance.

K.4.4.2 Isolation valves should be locked in the open position during normal operations.

K.4.5 System Operation

K.4.5.1 The EPCS should be arranged for automatic operation.

K.4.5.2 Where required by the fire department, the EPCS should be provided with a remote switch for manual activation.

K.4.5.3 An EPCS should be arranged to activate at a pressure not greater than 90 percent of the pressure relief device setting.

K.4.5.4 A dedicated, independent mechanical pressure switch or a combination of a mechanical and electronic pressure-sensing device dedicated to the EPCS should be provided to activate each EPCS.

K.4.5.5 Pressure sensing equipment should continuously monitor pressure in the refrigeration system adjacent to each crossover valve.

K.4.5.6 When a pressure sensor reaches the EPCS activation pressure, all of the following should occur:

1) All compressors supplying the pressure zone that is in an over-pressure condition should be stopped by a means that is independent of all other safety controls,

2) Associated crossover valves should open, and

3) Condenser fans and pumps should be stopped if the system pressure falls below 90 psig.

K.4.5.7 A means should be provided to signal personnel responsible for refrigeration system maintenance that an EPCS has been activated.

K.4.5.8 Once an EPCS has been activated, it should remain active until manually reset.

K.4.6 Inspection and Maintenance

K.4.6.1 General. EPCS crossover valves and isolation valves should be inspected and tested on an annual basis to verify proper operation.

K.4.7 Written Procedures

K.4.7.1 General. Written procedures should be in place to describe the operation of the EPCS. Procedures should address the importance of maintaining isolation valves in the full open position unless maintenance is being performed on the crossover valve.

Considerations for Pressure Set Points

Seep through a relief valve is nuisance refrigerant loss due to pressure differential conditions across the valve or dirt and debris located at the seat. Seep is measured in bubbles per minute and can vary from manufacturer, design, type of seat material, pressure differential across relief, amount of dirt that is trapped after a relief discharges, and age of the relief valve. Relief valves are set with a tolerance of +/- 3%, but when these reliefs are stored or left in operation for a long period of time, the reliefs can begin to seep at larger tolerances. In some cases, seep has occurred when pressure increases to within 10% of relief set pressure.

One method to prevent seep, is to maintain a pressure on the relief valve of 90% or less of the rated relief valve pressure setting. When pressures higher than 90% of rated relief valve pressure setting are anticipated, it is possible to select soft seats that are bubble tight at higher pressures. Rupture disks in combination with a relief valve will result in tighter tolerances.

The following tables show examples of typical tolerances and pressures associated with relief valves and the EPCS.

TABLE K-1

Typical Set Point Values and Tolerances for a 300 psig System

Relief Full Open (+10%)	330 psig
+3% tolerance	309 psig
Relief Valve Set Point	300 psig
-3% tolerance	291 psig
Potential seep point (-10%)	270 psig
EPCS set point (EPCS set point is equal or below the seep point)	250 psig to 270 psig
Design System Operating Pressure (-25%) (system operating pressure should be 25% lower than the relief valve setting when selecting relief valves)	225 psig
Compressor off set point	225 psig

TABLE K-2

Typical Set Point Values and Tolerances for a 250 psig System

Relief Full Open (+10%)	275 psig
+3% tolerance	257.5 psig
Relief Valve Set Point	250 psig
-3% tolerance	242.5 psig
Potential seep point (-10%) (EPCS set point is equal or below the seep point)	225 psig
EPCS set point	210 psig to 225 psig
Design System Operating Pressure (-25%) (system operating pressure should be 25% lower than the relief valve setting when selecting relief valves)	200 psig
Compressor off set point	200 psig

Appendix L (Informative)

Machinery Room Signage

The following example of the Principle and Auxiliary Machinery Room doors are provided for reference only.

Key to door signage:

1. **Refrigeration Machinery Room – Authorized Personnel Only**

   Color: Black Text, Yellow Background

   Location: All entrances to Machinery Room

2. **Caution – Ammonia R-717**

   Color: Black Text, Yellow Background

   Location: All entrances to Machinery Room

3. **Caution – Eye and Ear protection must be worn in this area**

   Color: Black Text, Yellow Background

   Location: All entrances to Machinery Room

4. **Warning – When alarms are activated ammonia has been detected**

   1. Leave room immediately when alarms are activated
   2. Do not enter except by emergency trained personnel only
   3. Do not enter without personal protective equipment

   Location: All entrances to Machinery Room

5. **Refrigeration Machinery Shutdown, Emergency use only**

   Color: Black Text, Orange Background

   Location: Designated principal exterior machinery room door.

6. **Refrigeration Machinery Room: Refrigeration Ventilation, Emergency use only**

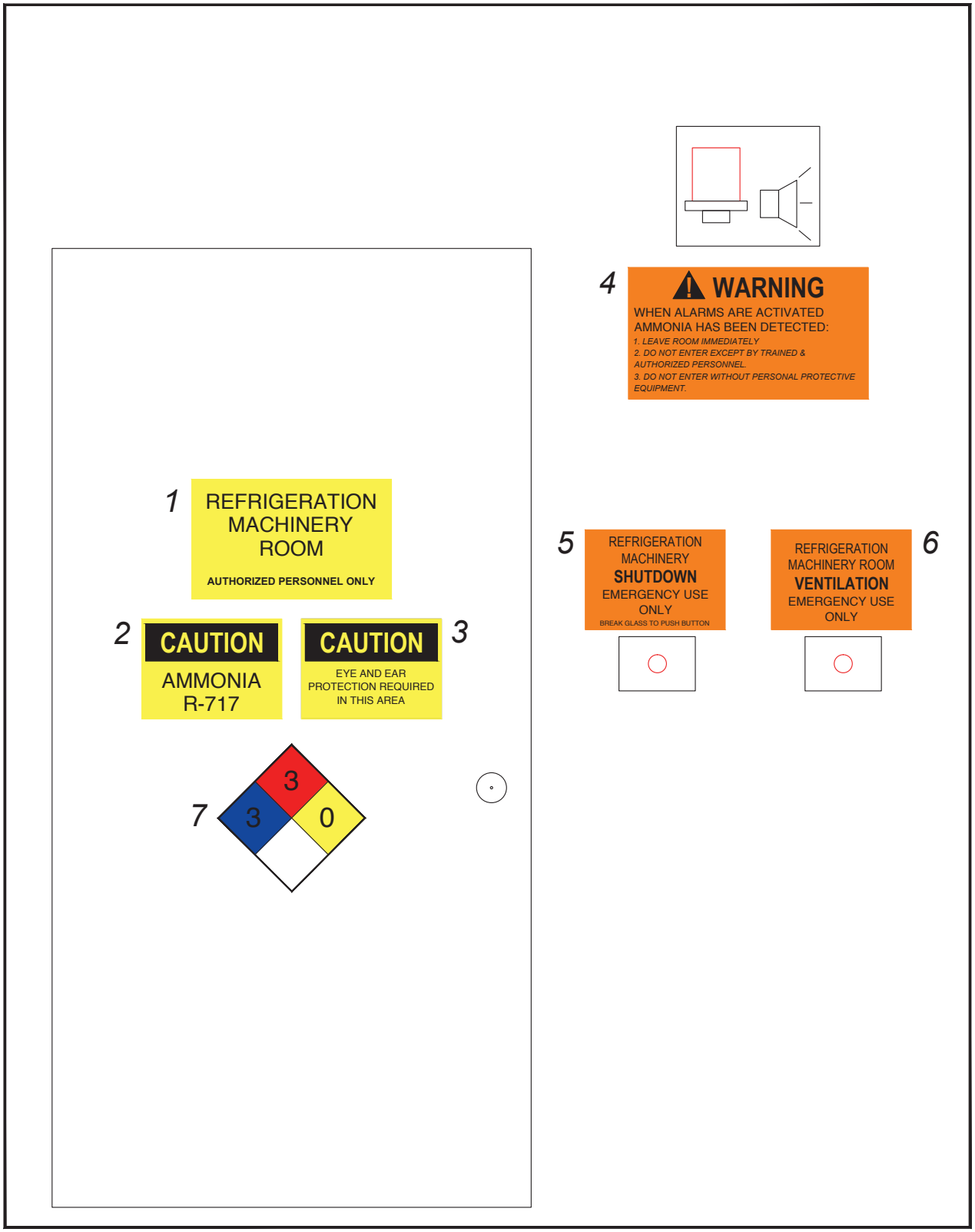
   Color: Black Text, Orange Background

   Location: Designated Principal Exterior Machinery Room Door, also can be used for remote On / OFF / AUTO ventilation switch.

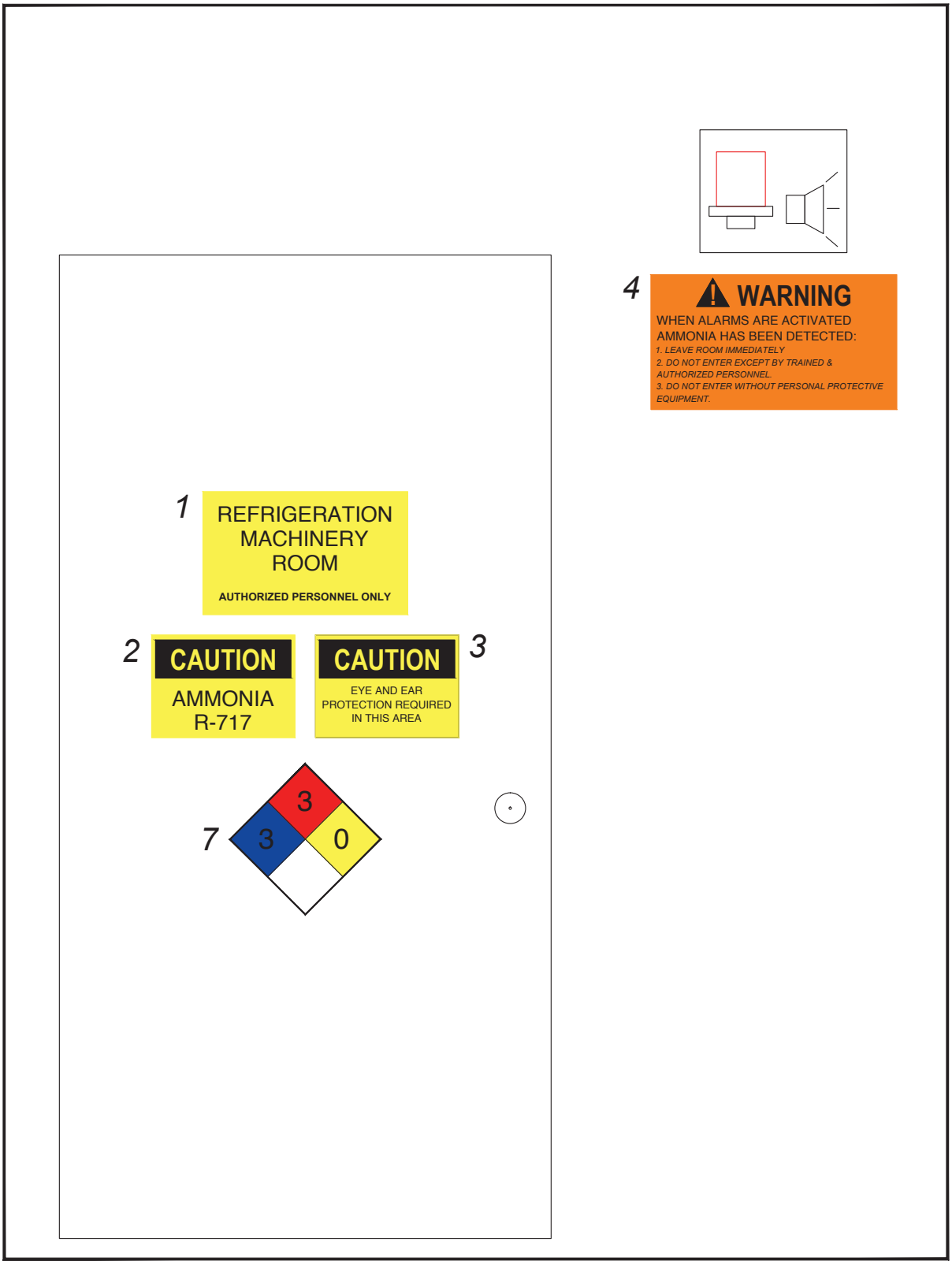
7. **NFPA 704 – Ammonia Fire Diamond**

   Color: Black Text, White, Blue, Red & Yellow Background

   Location: All entrances to Machinery Room



Principal Machinery Room Door



Auxiliary Machinery Room Door

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