BSR/IIAR 4-202X

Installation of Closed-Circuit Ammonia Refrigeration Systems

Public Review #1 Draft

Following are supplementary instructions for submitting comments:

1) Provide all of the commenter's contact information [e.g. name, phone number(s), and e-mail].

2) Identify the specific Section (i.e. by its Chapter and Section number) that is the subject of each comment(s).

3) Provide specific wording changes or action that would resolve the commenter's concern(s). Additions should be shown by underlining and deletions by strikethrough (i.e. Addition: include this, Deletion: ~~remove this~~), unless clearly shown in another method.

4) Provide a brief substantiation statement that presents the rationale, justification, and supporting documentation; as well as any technical data and backup. Provide an abstract for lengthy substantiations. If supplementary documents are provided to support your comment(s), electronic files in word processed (MS Word preferred) or scanned form are preferred. Indicate whether attachments have been provided. Highlighting pens should not be used since highlighted text will not reproduce.

5) If you do not understand the material, proceed with doing the necessary homework to gain understanding of the material and/or call the IIAR to discuss before commenting. Do not submit comments as opinions or questions.

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Notes on the Standard Text

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Foreword
(Informative)

This document is a standard for the installation of closed-circuit ammonia refrigeration systems and pressure relief device piping systems for overpressure protection when used in conjunction with a closed-circuit ammonia refrigeration system. Additional precautions may be necessary because of particular circumstances, project specifications, or other jurisdictional considerations. This standard does not constitute a comprehensive detailed technical installation manual and should not be used as such.

Experience shows that ammonia is very stable under normal conditions and rarely ignites when a release occurs because the flammability range in air is narrow and the minimum flammable concentration in air is very high as compared to other gases. Ammonia has a published flammability range of 160,000 ppm to 250,000 ppm. This concentration far exceeds ammonia's odor detection threshold and the 50-ppm permissible exposure level published by OSHA.

Ammonia's strong odor alerts those nearby to its presence at levels well below those that present either flammability or health hazards. 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 will dilute the vapor and greatly reduce exposure risk. Ammonia in vapor form is lighter than air. Typically, ammonia vapor rises and diffuses simultaneously when released into the atmosphere. It is biodegradable and, when released, 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 by the International Institute of Ammonia Refrigeration (IIAR) and was first approved by the American National Standards Institute (ANSI) in January 2015 as ANSI/IIAR 4-2015. ANSI/IIAR 4-202X was approved by ANSI on ???????.

This standard was prepared using the ANSI consensus method, whereby organizations and individuals having interest in the subject of the standard were contacted prior to the approval of this revision for participation on the Consensus Body and in public reviews. The standard was prepared and approved for submittal to ANSI by the IIAR Standards Committee and the IIAR Board of Directors.

Informative Appendix A *provides explanatory material related to provisions in the standard.* *Sections of the standard with associated explanatory information are marked with an asterisk "*" after the section number, and the associated appendix information is located in Appendix A with a corresponding section number preceded by "A."*

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

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The subcommittee responsible for writing this standard had the following members at the time of publication:

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Part 1 General

Chapter 1. Purpose, Scope and Applicability

1.1 Purpose

This standard specifies minimum requirements for the installation of safe closed-circuit ammonia refrigeration systems and pressure relief device piping systems for overpressure protection when used in conjunction with a closed-circuit ammonia refrigeration system.

1.2 Scope

Closed-circuit refrigeration systems utilizing ammonia as the refrigerant and pressure relief device piping systems for overpressure protection when used in conjunction with a closed-circuit ammonia refrigeration system shall comply with this standard.

1.3 Applicability

This is a standard for the installation of closed-circuit ammonia refrigeration systems and is not intended to supplant existing safety codes. In cases where the authority having jurisdiction (AHJ) has specific code requirements that are more stringent than those herein, that authority shall prevail.

1.3.1 This standard applies to:

1.3.1.1 Equipment and systems installed subsequent to adoption of this standard.

1.3.1.2 Ammonia absorption refrigeration systems.

1.3.1.3 Parts or components installed after adoption of this standard.

1.3.2 This standard does not apply to

1.3.2.1 Replacement of parts with functionally equivalent parts.

1.3.2.2 Equipment and systems installed prior to the effective date of this standard established by the AHJ. Such systems shall be maintained in accordance with regulations that applied at the time of installation.

1.3.3 **Alternate Means and Methods.** The provisions of this standard are not intended to prevent the installation of a material or to prohibit a construction method not specifically prescribed in this standard, provided that any such alternative has been approved by the AHJ. An alternate material or method of construction shall be approved where the AHJ finds that the proposed design is satisfactory and complies with the intent of the provisions of this standard, and the material, method, or work offered is, for the purpose intended, at least equivalent of that prescribed in this standard in quality, strength, effectiveness, fire resistance, durability, and safety.

1.3.4 **Installations in locations without an Authority Having Jurisdiction (AHJ).** Where equipment or a system is installed in a jurisdiction without an AHJ, the designer is authorized to specify an alternative for installation, and the alternative shall be documented in the design documents and provided to the owner and the installer.

Chapter 2. Definitions

Definitions shall be in accordance with ANSI/IIAR 1-2017.

Chapter 3. Normative References

3.1 American Society of Mechanical Engineers (ASME)

3.1.1 ASME B&PVC, *Boiler and Pressure Vessel Code, Pressure Vessels,* Section VIII, Division 1 (2019).

3.1.2 ASME B31.5 (2019), *Refrigeration Piping and Heat Transfer Components*.

3.1.3 ASME B&PVC, *Boiler and Pressure Vessel Code,* Section IX-*Welding, Brazing and Fusing Qualifications* (2019).

3.1.4 ASME B16.5 (2017), *Pipe Flanges and Flanged Fittings.*

3.1.5 ASME B16.11 (2016 and errata 2017), *Forged Fittings, Socket-Welding and Threaded.*

3.1.6 ASME B16.20 (2017), *Metallic Gaskets for Pipe Fittings.*

3.1.7 ASME B16.21 (2016), *Nonmetallic Flat Gaskets for Pipe Flange.*

3.2 American Society for Nondestructive Testing

3.2.1 ASNT SNT-TC-1A (2016), Personnel Qualification and Certification in *Nondestructive Testing.*

3.3 American Society of Testing and Materials (ASTM)

3.3.1 ASTM A53/A53M-18 (2018), *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*.

3.3.2 ASTM A197/A197M-00 (2019), *Standard Specification for Cupola Malleable Iron*.

3.3.3 ASTM A182/A182M-19a (2019), *Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.*

3.3.4 ASTM A575-96 (2018), *Standard Specification of Steel Bars, Carbon, Merchant Quality, M Grade.*

3.3.5 ASTM C585-16 (2016), *Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Piping and Tubing.*

3.3.6 ASTM C680 (2019), *Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperature of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs.*

3.4 Environmental Protection Agency (EPA)

3.4.1 40 Part 68, Accidental Release Prevention Requirements: *Risk Management Plan Under Clean Air Act*.

3.4.2 Section 112(r)(1) of the Clean Air Act, *General Duty Clause*.

3.5 National Fire Protection Association (NFPA)

3.5.1 NFPA Standard 70, *National Electrical Code* (NEC) (2020).

3.5.2 NFPA Standard 704, *Identification of the Fire Hazards of Materials for Emergency Response* (2017).

3.6 **International Institute of Ammonia Refrigeration (IIAR)**

3.6.1 ANSI/IIAR 1-2017, *Definitions and Terminology Used in IIAR Standards*.

3.6.2 ANSI/IIAR 2-2014, Addendum A, *Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems*.

3.6.3 ANSI/IIAR 3-2017, *Ammonia Refrigeration Valves*.

3.6.4 ANSI/IIAR 5-2019, *Start-up of Closed-Circuit Ammonia Refrigeration Systems*.

3.6.5 ANSI/IIAR 7-2019, *Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems*.

3.7 **International Safety Equipment Association (ISEA)**

3.7.1 ANSI/ISEA Z358.1, *World Safety Standard for Emergency Eyewash and Shower Equipment* (2014).

3.8 **Occupational Safety and Health Administration (OSHA)**

3.8.1 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*.

3.8.2 29 CFR 1910.147, *Control of Hazardous Energy, ("Lockout/Tagout").*

3.8.3 29 CFR 1910.212, *General Requirements for All Machines*.

3.8.4 29 CFR1910.219, *Mechanical Power Transmission Apparatus*.

3.8.5 Section 5(a)(1), Occupational Safety and Health Act, *General Duty Clause.*

Part 2 Installation Requirements

Chapter 4. General Requirements

4.1 Verification of Installation

4.1.1 Ammonia refrigeration systems shall be installed in accordance with the design documents and specifications meeting the requirements of IIAR 2 and verified through documentation.

4.2 Supervision of Installation

4.2.1 Installation shall be executed by individuals who, through experience and appropriate training, have been verified that they have been taught the skills necessary to safely receive, transport, and install refrigeration equipment, piping, and components in a manner so as to assemble a complete refrigeration system and not harm themselves, others, or the structure in which the equipment is to be installed.

4.2.2 Individuals who are in training or others who do not have these skills may participate in the installation provided they are closely supervised by an individual(s) meeting the requirement of Section 4.2.1.

4.3 Safety Training

4.3.1 All individuals participating in the installation shall be trained in all applicable safety procedures prior to participating in the installation.

4.3.2 All individuals participating in the installation shall be equipped with and trained for the use of all necessary personal protective equipment (PPE) for their protection and safety devices for the protection of others working in their immediate area.

4.4 Contractor Responsibilities

4.4.1 In the United States, where refrigeration systems are subject to OSHA's Process Safety Management (PSM) Standard (29 CFR 1910.119) or EPA's Risk Management Plan (RMP) regulation (40 CFR Part 68), or both, the owner, contractors, and subcontractors shall meet the PSM/RMP contractor requirements when installing refrigeration systems, parts, components, piping, or a combination thereof.

4.4.2 *In the United States, all owners, contractors, and subcontractors shall meet the OSHA and EPA General Duty Clause requirements when installing refrigeration systems, parts, components, piping, or a combination thereof.

4.4.3 For refrigeration systems outside of the United States, contractors and subcontractors shall be verified as qualified to meet local regulations or the equivalence of Section 4.4.2 requirements when installing refrigeration systems, parts, components, piping, or a combination thereof, whichever is greater.

4.5 Welding of Pressure Containing Components

4.5.1 **Piping and Pressure Vessel Welding.** Piping and pressure vessel welding shall be in accordance with ASME, B&PVC, Section IX. This includes being in accordance with the Welding Process Specification (WPS), the Procedure Qualification Record (PQR), and the Welding and Welding Operator Performance Qualification Record (WPQR).

4.5.2 Contractor(s) shall provide verification of non-expiration of the Welder and Welding Performance Qualification Record (WPQR) for WPQRs past six (6) months of the initial qualification for each welder.

4.5.3 Piping weld joint acceptance criteria shall be in accordance with ASME B31.5.

4.5.4 Visual inspection of weld joints shall be in accordance with ASME B31.5.

4.5.5 NDE inspector shall perform inspections within their respective qualifications and certifications that are in accordance with SNT-TC-1A.

4.5.6 Pressure testing, leak checking, and evacuating shall be in accordance with ANSI/IIAR 5, *Startup of Closed-Circuit Ammonia Refrigeration Systems*.

4.5.7 Weld repair of pressure vessels shall be in accordance with ASME B&PVC, Section VIII.

4.5.8 Attachments to pressure vessels are allowed only at weld pads.

4.5.9 Low hydrogen welding electrodes shall be in a hermetically sealed container or packaging. When the container or packaging is opened, low hydrogen welding electrodes shall be kept in a thermally controlled oven per the manufacturer's recommendation. Low hydrogen welding electrodes shall not be kept out of the oven for more than four (4) hours or as specified by the manufacturer.

4.6 Welding of Structural Supports

4.6.1 Welding of structural supports for refrigeration equipment and piping shall be in accordance with American Welding Society AWS D1.1, AWS D1.6, and AWS D1.8. This includes being in accordance with the Welding Process Specification (WS), the Procedure Qualification Record (PQR), and the Welder and Welding Operator Performance Qualification Record (WPQR).

4.6.2 Contractor(s) shall provide verification of non-expiration of the Welder and Welding Performance Qualification Record (WPQR) for WPQR's past six (6) months of the initial qualification for each welder.

4.7 Materials

4.7.1 **General.** All materials used in the installation of the equipment designated in Sections 6 –11 shall be suitable for ammonia refrigerant per Section 4 at the coincident temperature and pressure to which the component shall be subjected. No materials shall be used that will deteriorate in the presence of ammonia refrigerant, lubricating oil, or a combination of both.

4.7.2 Branch connections shall be installed in accordance with ASME B31.5.

4.7.3 Fabricated pipe fittings are permitted provided they are in accordance with the requirements of ASME B31.5.

4.7.4 Zinc, copper, and copper alloys shall not be used to contain or be in contact with ammonia. Copper-containing anti-seize, lubricating compounds, or both shall not be used in contact with ammonia piping.

EXCEPTION: Copper as a component of brass alloys may be used for bearings or other non-refrigerant containment uses.

4.8 **Location of Components**

4.8.1 All equipment, pipe, fittings, valves, and components shall be positioned to ensure that clearances are provided for accessibility and service requirements per manufacturer's instructions.

4.8.2 *All components and piping shall be installed in such a manner that they are protected from physical and environmental damage.

4.8.3 Ammonia refrigeration piping and equipment are to be located and installed in such a way that adjoining structures or equipment will not impact any part of the refrigeration system in case of a seismic event.

4.8.4 Insulation or un-insulated refrigeration piping or components, whose surface temperature is expected to be at or below the dew point temperature at any time, shall not be located over electrical equipment shall be protected.

EXCEPTION: Where the potential for condensation above electrical equipment cannot be avoided, the electrical equipment shall be protected.

4.8.5 All components and piping shall be supported to allow for transport and rigging. Temporary support and bracing may be used. Stationary and temporary rigging points shall be provided as required for positioning components and piping.

4.8.5.1 Rigging devices shall be rated for the intended load and inspected for defects, such as knicks, frays, kinks, cuts, or abrasions. Rigging devices that are identified with indications of defects shall not be used and retired.

4.8.5.2 The rigging crane operator shall be trained, qualified, and certified.

4.8.6 All components and piping shall be spaced to allow for insulation as required, where applicable.

4.8.7 Equipment placed outdoors shall be installed in a restricted location and have a means of preventing unauthorized access.

4.8.8 Refrigerant piping crossing an open space that affords passageway shall not be less than 7.25 ft (2.2 m) above the floor, unless the piping is located against the ceiling of such space and is permitted by the authority having jurisdiction (AHJ).

4.8.9 Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be placed in any elevator, dumbwaiter, or other shaft containing a moving object, or to in any way hinder means of egress.

4.8.10 Refrigerant piping shall not be installed in an unrestricted stairway, stair landing, or means of egress, such as in designated areas for public visitors, guests, or vendors

4.8.11 Installing refrigerant piping underground is not prohibited. Any such piping installed underground shall be protected against corrosion.

4.9 **Support of Components**

4.9.1 Threaded anchors and threaded supports shall have a minimum of three (3) exposed threads after final hardware attachment.

4.9.2 Mechanically expanded concrete anchor bodies shall not be adjusted, such as axially spun, after being set.

4.10 **Installation Documentation**

4.10.1 *The owner or owner's designated representative shall specify the documentation requirements to be provided before, during, and after installation.

Part 3 Equipment Installation

Chapter 5. General Requirements

5.1 Applicability

This section applies to the following items which are utilized in closed-circuit ammonia refrigeration systems:

5.1.1 Compressors

5.1.2 Evaporators

5.1.3 Condensers

5.1.4 ASME pressure vessels

5.1.5 Refrigerant pumps

5.1.6 Noncondensable purgers

5.2 Requirements

5.2.1 All equipment shall be anchored and secured in accordance with the manufacturers' recommendations, when available. Equipment shall not be left unanchored or unsecured.

5.2.2 When threaded rod is used to suspend equipment, a double nut or other mechanical means shall be employed to ensure the equipment remains secured.

5.2.3 Foundations and supports for equipment shall be of noncombustible construction and capable of supporting loads imposed by such units. Foundations and supports shall be installed according to manufacturers' instructions.

5.2.4 Foundations and supports shall not impede drainage to floor drains.

5.2.5 All equipment shall be mounted in such a manner as to prevent excessive vibration from being transmitted to the building structure or to the equipment. Isolation materials are permitted between the foundation and equipment.

5.2.6 Electrical equipment and wiring shall be installed in accordance with NFPA Standard 70: National Electrical Code (NEC), state and local codes, and manufacturers' instructions.

5.2.7 Condensers constructed from galvanized steel shall be passivated to prevent corrosion.

5.2.8 All exposed rotating components (e.g., shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with 29 CFR 1910.212, *General Requirements for all Machines.*

Chapter 6. Piping Installation

6.1 General

This section applies to pipe, fittings, and valves for use in closed-circuit ammonia refrigeration systems.

6.1.1 Piping shall be supported in the field installation such that the joint withstands all anticipated loading, such as vibrations, frost, ice, snow, seismic, etc.

6.1.2 Piping supports shall be installed to retain pipe within the support. Pipe shall not be welded to supports except where permitted by ASME B31.5.

6.1.2.1 *Pipe retaining methods permitted include the use of tabs, external guides, and chocks.

6.1.3 Valves shall be installed according to the manufacturers' recommendations. Piping shall not be forced by prying, jacking, or other distortions to facilitate valve installation.

6.1.4 *Hot tap connections are not prohibited.

6.1.5 Hot tap connection joints and testing shall be in accordance with ASME B31.5.

6.2 *Pipe

6.2.1 Pipe shall be reasonably free of rust, scale, sand, and dirt, both internally and externally. Pipe head number and grade markings shall be clearly legible.

6.2.2 Pipe that is one-half inch (1/2") and smaller is not prohibited when the use is supplemental to instrumentation. Where the use of one-half inch (1/2") and smaller pipe is required in the engineering design, it shall be supported, protected, or both to prevent damage. See Section 6.6 for Threaded Joints.

6.2.3 Pipe shall be kept clean and free of debris during fabrication and assembly.

6.2.4 Pipe shall be stored or stored or stationed during installation so as to prevent contaminants from entering the system.

6.3 Refrigerant Valves

6.3.1 This section applies to valves used in the ammonia-containing and the lubricant-containing parts of the closed-circuit ammonia refrigeration systems. Valves, and their installation, shall comply with ANSI/IIAR 3-2017, *Ammonia Refrigeration Valves,* and ASME B31.5.

EXCEPTIONS:

Valves within the refrigerant-containing envelope of other equipment such as:

1) Slide valves in screw compressors.

2) Safety relief valves.

6.3.2 Valves shall be oriented in accordance with the respective manufacturer's instructions or as shown on the drawings.

6.3.3 Valve gasket materials shall match the valve manufacturer's specifications, be compatible with ammonia, and be of the dimensions specified. Flange bolts shall be tightened in accordance with Section 6.5.

6.3.4 *Valves with specific tightening requirements shall be installed in accordance with manufacturer's instructions.

6.3.5 Shut-off (Stop) valves connecting refrigerant-containing parts to atmosphere shall be capped, plugged, blanked, or locked closed at the completion of installation.

6.4 **Piping Fabrication and Assembly**

6.4.1 Valves shall be installed according to manufacturer's instructions.

6.4.2 Piping joints shall be supported and in alignment such that the joint assembly is not distorted or stressed during assembly and installation.

6.4.3 *Horizontal runs of wet suction or hot gas refrigerant piping shall slope to drain to equipment, such as a pressure vessel, float drainer, or equivalent.

6.5 **Flanges**

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

6.5.2 Gaskets shall be correctly dimensioned for the flange set.

6.5.3 Nuts, bolts, cap screws and washers shall meet manufacturer's requirements for the application per ASME B31.5. Bolt threads shall extend completely through the mating nut.

6.5.4 The fasteners shall be progressively tightened in a diametrically staggered (crisscross or star) pattern.

6.5.5 Flange sets with specialized tightening requirements shall be installed according to manufacturer's instructions.

6.6 **Threaded Joints**

6.6.1 Thread compound used in threaded joints shall be suitable for service in ammonia refrigeration systems.

6.6.2 Threaded joints that require seal welding shall be made up without any thread compound and shall meet all requirements of threaded joints.

6.6.3 Threaded joints shall be verified not to be used for refrigerant piping larger than two inch (2").

6.6.4 All threaded piping shall be verified to be a minimum of Schedule 80.

6.7 **Welded Joints**

6.7.1 Welded joints shall be fabricated as required by ASME B31.5 and ASME B&PVC, Section IX.

Chapter 7. Components and Controls Installation

This section applies to components and controls applied for use in closed-circuit ammonia refrigeration systems.

7.1 Visual Liquid Level Indicators

7.1.1 All visual liquid level indicators shall be inspected prior to installation. Any visual liquid level indicator glass found to have a scratch, chip, or any defect shall be not be installed.

7.1.2 Visual liquid level indicators shall be installed in accordance with manufacturer's instructions.

7.1.3 Gaskets shall be as recommended by the manufacturer.

7.1.4 The retaining ring for the visual liquid level indicator shall be installed according to specifications provided by the manufacturer.

Chapter 8. Insulation System Installation

8.1 General Insulation Installation

8.1.1 All insulation system related materials shall be delivered to the job site in clean, marked, and previously unused containers.

8.1.2 Storage of all insulation system related materials at the job site shall be indoors or in closed containers that will prevent moisture in the environment, such as rain, snow, mist, and dew, from contacting the materials and will also prevent sunlight from reaching the insulation system materials.

8.2 Pipe Support Installation

8.2.1 **Horizontal Pipe**

8.2.1.1 All pipe supports shall be installed external to the insulation system. That is, the insulation system shall rest on a metal pipe shield/saddle that, in turn, rests on the pipe support.

8.2.1.2 Where pipe shields/saddles are used, their curvature shall match the circumferential curve of the insulation system jacketing.

8.2.1.3 *Thickness (gauge) and length of sheet metal shields/saddles shall comply with the following Table 8.2.1.3:

Table 8.2.1.3

Shields for Insulated Pipe and Tubing (In inches)

Insulation Outer Diameter	Minimum Gauge Metal	Arc Length	Saddle Length	Radius
2.5	20	2.5	12	1.25
3	20	3	12	1.5
3.5	18	3.5	12	1.75
4	18	4	12	2
4.5	18	5	12	2.25
5	16	5.5	12	2.5
6	16	6.5	12	3
8	16	8.5	18	4
10	14	10.5	18	5
12	14	12.5	18	6
14	14	14.5	18	7
15	14	17	18	8
16	12	19	18	9
20	12	21	18	10
22	12	23	18	11
24	12	25	18	12
26	12	27	18	13
28	12	29.5	18	14
30	12	31.5	18	15

8.2.1.4 Insulation, vapor retarder, and jacketing shall be installed so as to have no circumferential/butt joints in the portion of the insulation system within the support location.

8.2.1.5 The insulation installed in the bottom half of the insulation system at pipe support locations shall have the density and strength necessary to provide support using a 3X safety factor. Consult insulation manufacturer if assistance is needed.

8.2.1.6 For two-layer (2-layer) insulation systems, the insulation at pipe supports shall be either two (2) layers or a single (1) layer can be used provided the butt ends of the single insulation layer at the pipe support are fabricated in a shiplap style so that the butt joints with the neighboring straight pipe insulation can be staggered.

8.2.2 **Vertical Pipe**

8.2.2.1 *When vertical pipe must be supported, this shall be done using internal supports that attach directly to the pipe or external supports located on the horizontal pipe attached to the top and bottom of the vertical section.

8.2.2.2 The insulation system shall be installed around these internal supports.

8.2.2.3 An insulation system equivalent to that used on the pipe shall be installed on these supporting devices for a distance from the outer surface of the insulation system of four (4) times the pipe insulation thickness and be terminated with a vapor stop.

8.2.2.4 Vapor stops shall be installed on either side of the elbows at the top and bottom of vertical sections less than or equal to four (4) feet tall.

8.2.2.5 Vapor stops shall be installed on either side of all internal supports on vertical sections greater than four (4) feet tall.

8.2.2.6 *When vertical pipe does not need to be supported but must be prevented from lateral movement, external guides shall be used around the insulation system. These external guides shall be tightened just enough to secure but not crush the insulation system.

8.3 ***Corrosion Inhibiting Coatings Installation**

8.3.1 *Prior to installation of the insulation, corrosion inhibiting coatings shall be applied to the metal surface in accordance with the design specifications. Reactive gels are not permitted for use on stainless steel.

8.3.2 Corrosion inhibiting coatings shall be mixed, applied, handled, and cured per manufacturer's instructions.

8.3.3 Corrosion inhibiting coatings shall follow manufacturer's instructions for achieving the proper thickness and coating continuity.

8.3.4 *Reactive gel shall not be applied to the metal substrate (pipe or vessel) in areas where a vapor stop will be adhered to the metal. Alternatively, a reactive gel can be applied to the entire metal substrate provided it is later removed from the metal area where the vapor stop will be adhered.

8.4 **Insulation Installation**

8.4.1 **General**

8.4.1.1 Insulation shall be installed per manufacturer's recommendations.

8.4.1.2 Insulation shall be installed on piping and equipment that is free of ice, frost, and moisture and the surfaces are dry.

8.4.1.3 Insulation near uninsulated valve groups shall be installed such that the valves are accessible for operation, repair, service or replacement without having to cut or remove the insulation. Insulation adjacent to uninsulated areas shall be terminated with a vapor stop located to allow clearance for the removal of any fasteners without requiring removal of any of the insulation system components.

8.4.1.4 For insulated valves, insulate up to the packing nut to allow for regular maintenance of the valves. Where insulation thickness does not allow for access to the packing nut, valves with extended bonnets shall be used or the insulation shall be trimmed below the packing nut and terminated with a vapor stop.

8.4.1.5 For uninsulated valve groups, piping, or equipment located indoors or in non-rooftop outdoor locations were the surface temperature will be below the dew point of the surrounding air, a means to prevent condensation from dripping onto the ground, product, or equipment below shall be installed.

8.4.1.6 Insulation on pipe, elbows, and fittings shall be installed with no unplanned voids, gaps, or holes.

8.4.1.7 Insulation on vessels shall leave the vessel nameplate (e.g., an ASME identifier) visible and any exposed edges of insulation at the nameplate shall be sealed using a vapor stop.

8.4.1.8 Insulation on equipment and vessels shall be installed with no unplanned gaps at insulation joints and with no unplanned holes in the insulation. Insulation on the cylindrical body of equipment or vessels shall be installed without voids between the equipment or vessel and the insulation. Voids between the equipment or vessel ends and the primary insulation shall be filled with permissible insulation material (e.g., polyurethane spray foam).

8.4.1.9 All systems with greater than three (3) inches of nominal insulation thickness and or with the pipe/vessel operating below 0°F shall use a double layer insulation system.

8.4.1.10 For single-layer insulation systems, all insulation joints shall be sealed with joint sealant. For double-layer insulation systems, only joints in the outer layer shall be sealed.

8.4.1.11 *Where used, joint sealant shall be applied to the entire joint face at a thin thickness while still achieving good adhesion.

8.4.2 Tie-In of New Insulation to Existing Insulated Pipe and Vessels

8.4.2.1 Damage to the existing insulation system as a result of pipe tie-in or demolition work shall be repaired prior to installation of the new insulation system.

8.4.2.2 The insulation system at the tie-in location shall be made continuous. In particular, the vapor retarder continuity shall be maintained across the tie-in location. Where the new and old insulation adjoin at the tie-in location, joint sealant shall be used in the manner specified in this standard.

8.4.2.3 Vapor retarder on the new insulation system shall overlap the vapor retarder on the existing insulation system such that it forms a continuous envelope around the insulation.

8.4.3 Straight Pipe

8.4.3.1 On single layer insulation systems, the longitudinal joints shall be located at the 3:00 and 9:00 positions (+/- 10%) on the pipe.

8.4.3.2 On double layer insulation systems, the inner layer longitudinal joints shall be located at the 12:00 and 6:00 positions (+/- 10%) on the pipe while the outer layer longitudinal joints shall be located at the 3:00 and 9:00 positions (+/- 10%) on the pipe.

8.4.3.3 On double layer systems, stagger insulation half sections of the inner layer so that butt joints are staggered between left and right half sections by six (6) to eighteen (18) inches.

8.4.3.4 On double layer insulation systems with factory applied vapor retarder, the butt joints of the outer insulation layer top and bottom pieces need not be staggered from each other. However, these butt joints shall be staggered from the butt joints of the inner layer by at least six (6) inches.

8.4.3.5 On double layer insulation systems with field applied vapor retarder, the butt joints of the outer insulation layer top and bottom pieces shall be staggered from each other by at least six (6) inches and staggered from the butt joints of the inner layer by at least six (6) inches.

8.4.3.6 Apply filament tape to hold any inner layer insulation in place on the pipe.

8.4.3.7 Apply filament tape to hold the outer layer in place on top of the inner insulation layer when using field applied vapor retarder.

8.4.3.8 *Outer layer using factory applied vapor retarder shall be held in place by the vapor retarder sealing/closure system.

8.4.4 Elbows and Fittings

8.4.4.1 Preformed two-piece (2-piece) insulation elbows shall be used where available in the necessary sizes.

8.4.4.2 For two-layer (2-layer) insulation systems, the insulation on elbows and fittings shall be a single layer with either standard flat butt joints or shiplap style so that the butt joints with the neighboring straight pipe insulation can be staggered.

8.4.4.3 Apply filament tape to hold any inner layer or single layer elbow and fitting insulation in place on the pipe.

8.4.4.4 Apply filament tape to hold the outer layer in place on top of the inner insulation layer when using field applied vapor retarder.

8.5 **Vapor Retarder Installation**

8.5.1 **General**

8.5.1.1 All pipe or vessels operating for any fraction of time at a temperature below ambient shall have a continuous vapor retarder applied to the outer surface of the insulation.

8.5.1.2 Vapor retarder shall be installed per manufacturer's recommendations.

8.5.1.3 The vapor retarder system shall be installed in such a manner that it forms a continuous envelope around the insulation.

8.5.1.4 All surfaces to which self-sealing lap (SSL) tape or vapor retarder adhesive tape will be adhered must be wiped clean of dust and dirt prior to application of the tape.

8.5.1.5 *Vapor retarder film and tape must not be applied at temperatures colder than allowed in the manufacturer's recommendations.

8.5.1.6 *All vapor retarder film and tape shall be applied in a smooth manner with a minimum of wrinkles.

8.5.1.7 *When SSL or vapor retarder tape is used to seal joints, it shall be smoothed into place to minimize wrinkles and bubbles.

8.5.1.8 The application of mastic to the edges of vapor retarder film at joints sealed with SSL or external vapor retarder tape is not required.

8.5.1.9 Any tears or holes in the vapor retarder shall be sealed with a vapor retarder tape that meets the same permeance as the vapor retarder film.

8.5.2 **Straight Pipe**

8.5.2.1 The vapor retarder over insulation on straight pipe can be factory applied to the outer surface of the outer insulation layer or be field applied to the outer surface of the insulation.

8.5.2.2 Vapor retarder lap/longitudinal joints shall be sealed with (SSL) tape applied inside the joint, vapor retarder tape applied on the outside of the joint, or both.

8.5.2.3 Vapor retarder butt joints shall be sealed with three (3) inch wide vapor retarder tape meeting the same permeance requirements as the film and which exhibits good adhesion to the underlying vapor retarder film. Wrap tape a minimum of 1.25 times around circumference [one and a quarter (1-1/4) circumferential wrap].

8.5.3 **Elbows and Fittings**

8.5.3.1 Application of vapor retarder to insulation at elbows and fittings shall occur in any of four (4) ways.

8.5.3.1.1 *Custom fabricated flat vapor retarder (VR) – A flat piece of suitable low permeance VR film is cut to a shape that can be wrapped around part or all of an elbow or fitting with minimum wrinkling and overlap. The joints of this flat VR are sealed with VR adhesive tape.

8.5.3.1.2 Vapor retarder adhesive tape can be wrapped around the elbow/fitting in a continuous or near-continuous spiral manner. Thinner gauge tapes are more flexible and easier to conform to the complex shapes of elbows/fittings but are sometime higher in water vapor permeance (~0.03 perms). In these cases, the tape is spiral wrapped around the elbow/fitting with a 50% overlap of successive courses which achieves a double layer of the tape and achieves the required permeance.

8.5.3.1.3 *Individual pieces of VR tape are applied to the surface of the insulation elbow/fitting. When complete, the insulation elbow/fitting must be completely covered by the tape at a thickness which will achieve the required water vapor permeance.

8.5.3.1.4 Mastic-fabric-mastic – Applied per manufacturer's recommendations. This will require a layer of vapor retarding mastic be applied to the surface followed by a layer of reinforcing cloth (typically coarse mesh fiberglass) embedded lightly in the surface of the wet mastic. This first layer of mastic is allowed to cure and then a second layer of mastic is applied. The thickness of each mastic layer as well as the final combined thickness of the mastic-fabric-mastic vapor retarder must be sufficient to achieve the required water vapor permeance as required by the project specification. This mastic system must be overlapped onto the film/sheet vapor retarder on neighboring straight pipe to ensure a continuous vapor retarder system.

8.5.3.2 Regardless of which of the above four (4) approaches are used, the VR at the elbow/fitting must be connected to the VR on the neighboring straight pipe so that the total VR system is continuous. For the elbow/fitting vapor retarder methods described in Sections 8.5.3.1.1, 8.5.3.1.2, and 8.5.3.1.3, this shall be done using VR adhesive tape. For the elbow/fitting retarder methods described in Section 8.5.3.1.4, this shall be done by overlapping the mastic-fabric-mastic onto to neighboring film/sheet vapor retarder.

8.5.4 **Vessels**

8.5.4.1 Cylindrical Portions of Vessel Bodies

8.5.4.1.1 For smaller diameter vessels, these areas are handled just like straight pipe but the vapor retarder will be field applied. SSL tape is used to seal lap joints and minimum three (3) inch wide VR tape is used to seal the butt joints.

8.5.4.1.2 For larger diameter vessels, flat pieces of vapor retarder film are applied to the outer surface of the insulation. These pieces cover part or all of the circumference of the vessel insulation. An adhesive compatible with the insulation and the vapor retarder is used to hold the VR in place on the outer surface of the insulation. Longitudinal joints of the VR are sealed with VR tape. Subsequent courses of VR film are applied in the same manner with at least a two (2) inch overlap of the preceding VR course and the circumferential joints between courses are sealed with minimum three (3) inch wide VR tape.

8.5.4.2 **Vessel Ends (Spherical or Other Shapes)**

8.5.4.2.1 *Flat pieces of vapor retarder film are cut and applied to the outer surface of the insulation on the vessel ends. The shape of these pieces will vary depending on the size and shape of the vessel head and the preference of the installer and/or specifier. An adhesive compatible with the insulation and the vapor retarder is used to hold the VR in place on the outer surface of the insulation.

8.5.4.2.2 Individual flat VR pieces are overlapped by at least two (2) inches and minimum three (3) inch wide VR adhesive tape is used to seal all joints. VR tape is also used to seal the VR flat pieces on the vessel ends to the VR film on the cylindrical vessel body.

8.6 **Jacketing Installation**

8.6.1 **General**

8.6.1.1 All jacketing is to be installed so that it completely covers the underlying insulation system. No gaps in the jacketing are allowed.

8.6.2 **Metal Jacketing Insulation**

8.6.2.1 Metal jacketing shall be installed per manufacturer’s recommendations.

8.6.2.2 Vessel and straight pipe jacketing joints, both lap and butt, must have at least a 2 inch overlap.

8.6.2.3 Vertical joints on vessels, butt joints on horizontal pipe, and lap joints on vertical pipe must be oriented to face away from prevailing winds, if present.

8.6.2.4 Horizontal joints on vessels, lap joints on horizontal pipe, and butt joints on vertical pipe must be oriented to naturally shed water which means that the mouth of the joint must face downward.

8.6.2.5 *Whether the metal jacket joints are sealed must be stated in the specification and if this requirement is present, the joint sealant (also called flashing sealant) shall be applied inside the joint and not on the outer lip of the joint.

8.6.2.6 On cold applications, screws, rivets or any other jacket securement device that could pierce the underlying vapor retarder must not be used. Only bands and seals are to be used to secure the jacketing.

8.6.2.7 Two-piece (2-piece) metal elbow/fitting jacketing shall be used when available in required size.

8.6.2.8 For sizes where two-piece (2-piece) metal elbow/fittings are not available, fabrication and use of gore elbows are acceptable.

8.6.2.9 Minimum lap joint overlap of two-piece (2-piece) metal elbow/fitting jacketing is (five-sixteenth) 5/16 inch with a target overlap of (five-eighth) 5/8 inch when the insulation outer diameter meets the requirements of ASTM C585.

8.6.2.10 Lap joints in two-piece (2-piece) metal elbow/fitting jacketing shall be oriented to naturally shed water for horizontal elbows and to face away from any prevailing winds for vertical elbows.

8.6.3 ***PVC Jacketing Installation**

8.6.3.1 PVC jacketing shall be installed per manufacturer's recommendations.

8.6.3.2 PVC jacketing shall have all joints sealed with suitable adhesive or PVC weld cement except required expansion/contraction joints.

8.7 Vapor Stop Installation

8.7.1 For all insulation systems that require a vapor retarder and where the specifications requires the installation of vapor stops, install the vapor stops at the following locations:

8.7.1.1 On either side of every insulation system penetration (e.g. valve stems, internal supports, and inspection ports).

8.7.1.2 At all insulation terminations including those on internal supports, stanchions, and vessel legs.

8.7.1.3 At the top and bottom of vertical sections less than or equal to four (4) feet tall.

8.7.1.4 On either side of all internal supports on vertical sections greater than four (4) feet tall.

8.7.1.5 *Every eighteen (18) feet of straight pipe.

8.7.2 Vapor stops shall be constructed from vapor retarder mastic and reinforcing cloth mesh or from vapor retarder tape.

8.7.3 The permeance of the vapor stop shall be equal to or lower than the requirements for the primary vapor retarder.

8.7.4 Install vapor stops per mastic and insulation manufacturer's instructions.

8.7.5 Vapor stop must adhere to the pipe, go up the face of the insulation, and adhere to the vapor retarder.

8.7.6 Installer must plan for the presence of vapor stops and assure that jacketing will fit over the vapor stops and that corrosion inhibiting gel (if used) is not present or is removed at the location where the vapor stop will adhere to the pipe.

8.8 **Expansion/Contraction Joint Installation**

8.8.1 The specification shall state the requirement for expansion/contraction joints in the insulation system, their spacing, and their design.

8.8.2 Insulation manufacturer's recommendations shall be consulted when determining design, spacing, and installation methods for expansion/contraction joints.

8.8.3 Vapor retarder integrity shall be maintained across expansion/contraction joints.

8.8.4 Expansion/contraction joints shall not be used on the innermost layer of multi-layer insulation systems. Where a three (3) layer insulation system is installed, the expansion/contraction joints in the second (2nd) and third (3rd) layers shall be offset from each other.

Part 4 Appendices

Appendix A. (Informative) Explanatory Material

This informative appendix is not a part of the standard. It provides explanatory information related to provisions in the standard. Sections of the standard that have associated explanatory information in this appendix are marked with an asterisk "*" after the section number, and the associated appendix information is located in a corresponding section number preceded by "A".

A.4.4.2 The IIAR's Ammonia Refrigeration Management (ARM) Program contains a Contractor Program that can be used to ensure that refrigeration contractors and subcontractors are qualified to work on ammonia refrigeration systems.

A.4.8.2 Physical damage to avoid includes impact by vehicular and material handling equipment traffic.

A.4.10.1 For procurement documentation considerations, see Appendix B.

A.6.1.4 See ASME B31.5 Section 538 and Section 504.3. When utilized, Hot Tapping shall follow hot tap equipment manufacturers' procedures and site specific safe work practices.

A.6.1.2.1 The most common type of external guides used is a U-bolt.

A.6.2 It is recommended that when the grades of un-galvanized pipe are used, the pipe is clearly identified with paint striping to prevent their use in the closed-circuit ammonia refrigeration systems.

A.6.3.4 Valve components with specific tightening requirements could include bonnets, packing glands, pilots, caps, sight glasses, adapters, and/or plugs.

A.6.4.3 Sloped refrigerant pipe for wet suction or hot gas should be installed per the design of the system. If no slope is specified in the design, refer to the IIAR Refrigeration Piping Handbook.

A.8.2.1.3 Compliance to these thickness (gauge) and length requirements will prevent flexing of the sheet metal shield/saddle which would concentrate forces into a smaller area of the insulation that supports the pipe. The Table 8.2.1.3 *Shields for Insulated Pipe and Tubing* information can be found in IIAR's (2019) *The Refrigeration Piping Handbook,* Table 7-1.

A.8.2.2.1 External supports, which are the required support method for horizontal pipe, cannot be used on vertical pipe because the clamping force necessary to prevent the pipe or insulation system from sliding at the support location would crush the insulation system. Vertical pipe may not need support if standard external supports are used on the horizontal pipe at the top and bottom of the vertical section.

A.8.2.2.6 The most common type of external guides used is a U-bolt.

A.8.3 The corrosion inhibiting coating should be a suitable paint or gel.

A.8.3.1 All carbon steel operating at a service temperature between 32°F and 250°F or in cycling temperature service where the service temperature is between 32°F and 250°F for more than 20% of the time should have a corrosion inhibiting material applied to the surface under the insulation.
All austenitic stainless steel operating at a service temperature between 140°F and 250°F or in cycling temperature service where the service temperature is between 140°F and 250°F for more than 20% of the time shall have a corrosion inhibiting paint (e.g. epoxy based paint, enamel primer, or urethane based paint) applied to the surface under the insulation.

A.8.3.4 Cleaning/removal of the reactive gel is done with a cloth and a d-limonene (citrus) based cleaner.

A.8.4.1.11 Joint sealant has poor (high) thermal conductivity compared to insulation. When joint sealant is applied as a thick layer, it provides a small location of relatively poor insulating ability to the insulation system. This type of location is often called a "thermal short". To minimize the impact of joint sealant on insulating ability, the joint sealant should be applied across the entire joint face in as thin a layer as can be reasonably achieved while still achieving good adhesion of the insulation pieces at that joint. By installing the joint sealant across the entire joint face, the width of the joint sealant through which water vapor would have to permeate in order to pass through the insulation system is maximized.

A.8.4.3.8 The vapor retarder sealing/closure system is not designed to hold the insulation system in place for the long-term. Rather, it holds the insulation system in place temporarily until the outer protective jacket is installed.

A.8.5.1.5 At colder temperatures, the vapor retarder films can lose flexibility and the adhesives on the tapes can exhibit reduced adhesion.

A.8.5.1.6 Note that vapor retarder tape wrapped around fittings and elbows will inevitably have some wrinkles.

A.8.5.1.7 Smoothing of self-sealing lap tape and vapor retarder tape is done with a flexible but not sharp tool, such as a rubber squeegee.

A.8.5.3.1.1 This will always involve some bending, folding, or wrinkling of the film VR but if done with a minor amount of this, it is acceptable. A commonly used technique is to cut the film VR to fit on the left or right half of a two-piece (2-piece) insulation elbow/fitting.

A.8.5.3.1.3 This approach can be used to reduce the amount of tape that builds up in the throat of some elbows when the spiral wrapping approach is used.

A.8.5.4.2.1 Examples of possible shapes include roughly triangular and roughly trapezoidal.

A.8.6.2.5 Sealing of metal jacketing joints is controversial. Some believe the joints must be sealed with adhesive to help prevent water entry. Others believe that water entry through the metal jacketing is inevitable and the joints must be left unsealed to allow evaporation of this water. This topic has not been studied scientifically so the only information available is anecdotal.

A.8.6.3 PVC (polyvinyl chloride) jacketing should not be installed in outdoor locations where it will be directly exposed to sunlight or ambient cold temperatures which will cause excessive embrittlement of the PVC. This would typically be ambient temperatures below about 0 degrees F.

A.8.7.1.5 This is done to limit the spread of moisture inside the insulation system if the vapor retarder becomes damaged at a location.

Appendix B. (Informative) Installation Documentation

Installation documentation considerations to request during procurement where applicable (Part of Purchase Order/Contract Order):

B.1 BEFORE INSTALLATION:

- Warranty Letter (Certification) – Normally included in proposal
- Copies of structural engineering calculations, structural drawings, and civil works
- Block Flow & Piping & Instrumentation Diagrams (P&IDs)
- Piping/Equipment Layout(s)
- Safe Work Plans
- Hazard Safety Review or Assessment and/or Process Hazard Analysis (PHA)
- Welder Process Specification (WPSs)
- Welder & Welding Operator Performance Qualification Record (WPQRs)
- Welder Certifications

B.2 DURING INSTALLATION

- Certified Material Test Reports (CMTRs) for piping and fittings, or in the absence of CMTRs, a Certificate of Compliance from contractor indicating the specification of the material supplied and installed
- Shop Drawings for pressure vessels and equipment

B.3 AFTER INSTALLATION

- As-Built Drawings – Upon full installation completion
- Inspection Reports
- Nondestructive Evaluation (NDE) Reports
- Weld Maps
- Work-In-Progress Inspection/Testing Reports
- Testing Documentation – Per ANSI/IIAR 5-2019 requirements
- Certificate of Compliance indicating Standards and Codes followed for installation
- Welding Documents (Per Section 4.4.1 and 4.4.2) and Welder Continuity Report(s)
- Line Break Permit(s)
- Electrical Field Wiring & Ladder Wiring Diagrams
- PLC Programming
- Process Safety Information (PSI) Installation Updates – Where PSM regulated
- Installation Specifications and Drawings
- Block Flow & Piping & Instrumentation Diagrams (P&IDs) – when completed
- Equipment/Valve Lists
- Ammonia Charge Calculations
- Ammonia Delivery Bill of Lading/Invoice(s) and Delivery Receipts
- Safety System & Relief Data
- Material & Energy Balance

- Pressure Vessel Data Forms & All U-Stamped Equipment
- ASME U1-A, U-2, U-3 Forms
- Equipment and/or System Operation & Maintenance Manuals
- Pressure Relief Valve (PRV) Calculations
- Relief Discharge Line/Header System Calculations
- Machinery Room Ventilation Calculation & Ventilation System Data
- Change Management or Management of Change (MOC)
- Hazard Safety Review or Assessment and/or Process Hazard Analysis (PHA) – Final
- Pre-Startup and Safety Review (PSSR)
- Standard Operating Procedures
- Training Records

Additional Items to be submitted for installation close out:
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Appendix C. (Informative) Safety Concerns Related to Insulation

There are four (4) key safety aspects of an ammonia refrigeration system related to the insulation used on the pipe, vessels, and equipment.

A) Reducing the likelihood of metal pipe/vessel corrosion under insulation (CUI) so as to reduce the risk arising from loss of ammonia containment.

B) Reducing the likelihood of condensation on the outer surface of insulation systems in indoor locations so as to reduce the risk arising from slips, contaminated food/beverage, electrical shorts, corrosion, and mold/fungal growth. The first (1st) three (3) of these arise from condensation on the outer surface of the insulation system dripping onto something below like the floor, electrical items, or stored food/beverage. The last two (2) of these is caused either from dripping condensation or by the presence of water on the outer surface of the insulation system itself.

C) Reducing the likelihood of condensation on the outer surface of insulation systems in outdoor non-rooftop locations so as to reduce the risk arising from slip hazards. Rooftop locations are excluded from this aspect since slip hazards due to condensation are not a significant concern on rooftops. The concerns over contaminated food/beverage, electrical shorts, corrosion, and mold/fungal growth are excluded from this section as these are not deemed a concern in an outdoor location.

D) Reducing the likelihood of weight changes in the pipe/insulation system adversely affecting the pipe/vessel supporting structure. Specifically, this involves reducing the risk arising from water intrusion into the insulation system and ice formation on or in the insulation system.

<u>COMMONALITY OF ALL INSULATION RELATED SAFETY CONCERNS:</u>

All of the ammonia refrigeration safety concerns related to insulation are related to water collecting in or on the insulation system. Of course, this water will turn to ice if the temperature of the insulation system interior or surface is cold enough.

The requirements of this chapter are targeted at preventing collection of water in or on the insulation system as the way to prevent all of the above four (4) safety concerns.

Appendix D. (Informative) Insulation System Design & Material Selection

The majority of this appendix deals with insulation system design and material selection which is outside the scope of IIAR #4. This section would be appropriate for inclusion into IIAR #2 but will remain as an informative appendix in IIAR #4 until such time as it is moved to IIAR #2.

<u>INSULATION THICKNESS AND INSULATION MATERIAL SELECTION</u>

1. The insulation thickness used shall be designed to prevent condensation on the outer surface of the insulation system and to limit the heat transfer through the insulation system to a maximum of 8 Btu/hr-ft2 of outer jacket surface at harsh design conditions. Calculations of required insulation thickness and heat gain shall use the methodology of ASTM C680.

    a. Outdoors, these harsh design conditions shall be:
        i. Actual pipe/vessel orientation (horizontal or vertical pipe, vessel sides, vessel top, or vessel bottom) and actual pipe size.
        ii. Actual coldest pipe/vessel service temperature planned for that object.
        iii. Emittance of the insulation system outer surface (lower emittance such as from unpainted aluminum is a harsher condition).
        iv. A very high ambient temperature reflective of the hottest or near hottest ambient temperature the insulation system is expected to encounter (higher ambient temperature is a harsher condition).
        v. 7 mph wind, or less if the pipe/vessel is shielded from the wind (lower wind speed is a harsher condition).
        vi. A very high relative humidity not less than 85% R.H. (higher relative humidity is a harsher condition).
        vii. The thermal conductivity for the insulation material taken from the relevant ASTM standard specification for that material type.

    b. Indoors, these harsh design conditions shall be:
        i. Actual pipe/vessel orientation (horizontal or vertical pipe, vessel sides, vessel top, or vessel bottom) and actual pipe size.
        ii. Actual coldest pipe/vessel service temperature planned for that object.
        iii. Emittance of the insulation system outer surface (lower emittance such as from unpainted aluminum is a harsher condition).
        iv. A very high ambient temperature reflective of the hottest or near hottest ambient temperature the insulation system is expected to encounter (higher ambient temperature is a harsher condition).
        v. 0 mph wind. In rare cases where all of the pipe/vessel will be exposed to constant air movement, the use of a wind speed of 1-2 mph is acceptable (lower wind speed is a harsher condition).
        vi. A very high relative humidity not less than 85% R.H. (higher relative humidity is a harsher condition). In rare cases where the pipe/vessel insulation is located in a climate controlled space and where this climate control will always be operating, the use of relative humidity of 60-85% is acceptable.
        vii. The thermal conductivity for the insulation material taken from the relevant ASTM standard specification for that material type.

2. Insulation material shall be 90% or greater closed-cell and shall be selected from the following materials which are the only ones listed in the IIAR Piping Handbook chapter on insulation.
    a. Extruded polystyrene (XPS) insulation compliant with ASTM C578, Type XIII or IV
    b. Polyisocyanurate (PIR) insulation compliant with ASTM C591, Grade 2
    c. Phenolic insulation compliant with ASTM C1126, Type III
    d. Cellular glass compliant with ASTM C552, Type I, Grade 6 for vessel applications and Type II for pipe applications

3. Insulation shall be fabricated to comply with ASTM C450 or C585

<u>VAPOR RETARDER MATERIAL SELECTION</u>

1. Vapor retarder material used shall have a water vapor permeance per ASTM E96, Procedure A (desiccant method) of 0.02 perms, maximum, when used on pipe/vessel operating between 0°F and ambient temperature and 0.01 perms, maximum, when used on pipe/vessel operating below 0°F. Vapor retarder adhesive tape with a permeance of greater than 0.02 perms is acceptable for use at insulation fittings and at vapor retarder joints provided it is applied in enough layers to achieve a permeance of 0.02 perms or less.

2. Vapor retarder material containing exposed paper such as ASJ or FSK shall not be used.

3. Vapor retarder tape shall have a factory applied pressure sensitive adhesive on one (1) side. Release paper covering the adhesive may be used but is not required.

4. Vapor retarder must comply with ASTM C1136, Types VII, VIII, IX, or X; ASTM C1775; or be a rubberized membrane with a permeance not exceeding 0.02 perms. There is currently no ASTM standard specification for rubberized membrane vapor retarders.

<u>JOINT SEALANT MATERIAL SELECTION</u>
All joint sealant used in the insulation joints shall have sufficiently low water vapor permeability that the combination of this performance and the width of the sealant layer at the joint shall combine to yield a water vapor permeance of no greater than 0.02 perms.

<u>JACKETING MATERIAL SELECTION</u>

1. PVC Jacketing
    a. PVC jacketing shall only be used in indoor locations.
    b. The PVC jacketing thickness used must be strong enough to withstand the anticipated physical abuse it will receive but shall never be less than 0.020 inches (20 mils) thick.
    c. In situations where very high physical abuse is expected or improved fire performance is needed, the jacketing shall be aluminum.
    d. Preformed PVC elbow/fitting jacketing shall be used when available in required size.
    e. PVC jacketing shall never be considered to be a vapor retarder.

2. Aluminum Jacketing
    a. In outdoor locations, the jacketing shall be minimum 0.016 inch thick aluminum.
    b. Aluminum jacketing shall comply with ASTM C1729 as follows:

i. Jacketing on straight pipe shall comply with Type I, II, or III; Grade 1, Class A.
ii. Jacketing on 2-piece preformed pipe fittings/elbows shall comply with Type II; Grade 3, Class A.
iii. Jacketing on vessels and equipment shall comply with Type I, II, or III; Grade 1, 5, or 6; Class A, D, or E.

c. Aluminum jacketing shall have a 3 mil (76 micron) three (3) layer polyfilm moisture barrier factory heat laminated to the interior surface to help reduce the likelihood of corrosion occurring on the interior surface of the jacketing.
d. Two-piece (2-piece) preformed metal elbow/fitting jacketing shall be used when available in required size. For sizes where two-piece (2-piece) metal elbow/fittings are not available, gore elbows are acceptable.

<u>METAL JACKETING SECUREMENT MATERIAL SELECTION</u>

1. Metal jacketing shall be secured with either stainless steel bands or stainless steel screws.

2. In any application that requires a vapor retarder over the insulation, only bands shall be used to secure metal jacketing. Screws or any other metal jacket securement device capable of damaging the underlying vapor retarder shall not be used.

3. Stainless steel banding shall be either 0.015 or 0.020 inches thick and one-half (½) or three-quarter (¾) inch wide and shall be secured with stainless steel wing seals.

<u>CORROSION INHIBITING COATINGS MATERIAL SELECTION</u>

1. There are two (2) commonly used classes of materials applied to metal surfaces to prevent CUI. These are reactive gels and paints/coatings.

2. Paints shall consist of a minimum five (5) mil thick epoxy based primer followed by a minimum five (5) mil thick epoxy based finish coat. These epoxy based paints are usually two-part (2-part) paints with a limited window of time for application once the two (2) parts are combined.

3. Reactive gel materials shall be a hydrocarbon based surface conversion compound corrosion control gel.

Appendix E. (Informative) References and Sources of References

E.1 Informative References

E.1.1 Compressed Gas Association G-2, 1995, Eighth Edition.

E.1.2 International Institute of Ammonia Refrigeration (IIAR):

E.1.2.1 *IIAR Refrigeration Piping Handbook,* 2019.

E.1.2.2 *Ammonia Refrigeration Management (ARM) Program*.

E.1.3 Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Governing editions:

E.1.3.1 29CFR1910.212, *General Requirements for All Machines*.

E.1.3.2 29CFR1910 subpart D, *Walking-Working Surfaces*.

E.1.3.3 29CFR 1926.1053, subpart X, *Ladders*.

E.1.3.4 29CFR 1926.56, subpart D, *Illumination*.

E.1.4 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), ANSI/MSS Standard Practice SP 58-2009, *Pipe Hangers and Supports, Selection and Application*.

E.1.5 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

E.1.5.1 2010 ASHRAE Handbook — *Refrigeration, System Practices for Ammonia Refrigerant*, Chapter 2, page 2.8.

E.1.5.2 Standard 15-2019, *Safety Standard for Refrigeration Systems*.

E.1.6 American Society of Testing and Materials (ASTM), Editions as shown below:

E.1.6.1 ASTM A105/A105M-18, *Standard Specification for Carbon Steel Forgings for Piping Applications*.

E.1.6.2 ASTM A106/A106M-19a *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*.

E.1.6.3 ASTM A181/A181M-14, *Standard Specification for Carbon Steel Forgings, for General-Purpose Piping*.

E.1.6.4 ASTM A193/A193M-19, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*.

E.1.6.5 ASTM A234/A234M-19, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service*.

E.1.6.6 ASTM A307-14e1, *Standard Specification for Carbon Steel Bolts and Studs*, 60,000
PSI Tensile Strength.

E.1.6.7 ASTM A312/A312M-19, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*.

E.1.6.8 STM A320/A320M-18, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service*.

E.1.6.9 STM A333/A333M-18, *Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service*.

E.1.6.10 ASTM A403/A403M-19a, *Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.*

E.1.6.11 ASTM A420/A420M-19a, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service*.

E.1.6.12 ASTM A707/A707M-19, *Standard Specification for Forged Carbon and Alloy Steel Flanges for Low-Temperature Service*.

E.1.6.13 ASTM C450-18, *Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging.*

E.1.6.14 ASTM C552-17e1, *Standard Specification for Cellular Glass Thermal Insulation.*

E.1.6.15 ASTM C578-19, *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.*

E.1.6.16 ASTM C585-10(2016), *Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Piping and Tubing.*

E.1.6.17 ASTM C591-19a, *Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.*

E.1.6.18 ASTM C1126-19, *Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.*

E.1.6.19 ASTM C1136-17a, *Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.*

E.1.6.20 ASTM C1729-19, *Standard Specification for Aluminum Jacketing for Insulation.*

E.1.6.21 ASTM C1775-14, *Standard Specification for Laminate Protective Jacket and Tape for Use over Thermal Insulation for Outdoor Applications.*

E.1.6.22 ASTM E96/E96M-16, *Standard Test Methods for Water Vapor Transmission of Materials.*

E.1.7 U.S. Department of Transportation (US DoT), 49 CFR Part 172, *Hazardous Materials Regulations*, 2017.

E.1.8 International Safety Equipment Association (ISEA), ANSI/ISEA Z358.1, *World Safety Standard for Emergency Eyewash and Shower Equipment*, 2014.

E.2 Sources of References

E.2.1 American National Standards Institute (ANSI) 25 West 43rd Street, 4th Floor
New York, NY 10036
www.ansi.org

E.2.2 American Petroleum Institute (API) 1220 L Street NW
Washington, DC 20005-4070
www.api.org

E.2.3 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)
1791 Tullie Circle, N.E.
Atlanta, GA 30329
www.ashrae.org

E.2.4 American Society of Mechanical Engineers (ASME)
ASME International
Two Park Avenue
New York, NY 10016-5990
www.asme.org

E.2.5 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

E.2.6 International Institute of Ammonia Refrigeration (IIAR)
1001 N. Fairfax St., Suite 503
Alexandria, VA 22314-1797
www.iiar.org

E.2.7 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
127 Park Street, N.E.
Vienna, VA 22180
www.mss-hq.com

E.2.8 National Fire Protection Association (NFPA)
60 Batterymarch Park
Quincy, MA 02169-7471
www.nfpa.org

E.2.9 U. S. Department of Labor/OSHA
Publications Department
200 Constitution Avenue, NW, Room N3101 Washington, DC 20210
www.osha.gov

E.2.10 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