IIAR 6-202x

Inspection, Testing, and Maintenance of Closed-Circuit Ammonia Refrigeration Systems

IIAR 6

Public Review #1 Draft

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Notes on the Standard Text

Metric Policy

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

Normative and Informative Elements

This standard includes normative (required) provisions. The foreword and appendices are informative, or nonmandatory. Informative material shall never be regarded as a requirement.

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ANSI Status of this Document

This proposed standard revision is not a final standard and shall not be used in place of an American National Standard. Reproduction of this document is permitted solely for the purpose of public review. Distribution of this

Foreword
(Informative)

This document is a standard for the minimum requirements for inspection, testing, and maintenance (ITM) applicable to safe closed-circuit ammonia refrigeration systems. This standard reflects the consensus reached by ammonia refrigeration industry practitioners for inspection, testing, and maintenance requirements. This standard is intended to be incorporated as part of a Mechanical Integrity (MI) Program as recognized and generally accepted good engineering practices (RAGAGEP). This standard can be used for performing a gap analysis for minimum safe requirements of an owner's existing ITM tasks pertaining to closed-circuit ammonia refrigeration systems. Regarding Mechanical Integrity, this standard is not intended to serve as a comprehensive, detailed technical inspection, testing, and maintenance manual and shall not be used as such. This standard is not Mechanical Integrity written maintenance procedures, developed preventive maintenance (PM's), maintenance training, an audit, or a quality assurance program.

This standard defines the minimum requirements for ITM tasks of safe closed-circuit ammonia refrigeration systems. Additional precautions may be necessary because of particular circumstances, project specifications, or other jurisdictional considerations. The IIAR Process Safety Management & Risk Management Program Guidelines address United States regulatory requirements for facilities with systems containing 10,000 pounds or more of ammonia and the IIAR Ammonia Refrigeration Management Program (ARM) addresses United States regulatory requirements for facilities with less than 10,000 pounds of ammonia.

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 with other ignitable 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 limit (PEL) published by the Occupational Health and Safety Administration (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, because 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.*

ANSI/IIAR 6-202x was approved by ANSI on Month, Day, 202x which supersedes ANSI/IIAR 6-2019.

The original standard replaced IIAR Bulletin No. 108 *Guidelines for: Water Contamination in Ammonia Refrigeration Systems,* IIAR Bulletin No. 109 *Guidelines for: IIAR Minimum Safety Criteria for a Safe Ammonia Refrigeration System,* IIAR Bulletin No. 110 *Guidelines for: Start-Up, Inspection, and Maintenance of Ammonia Mechanical Refrigerating Systems,* and IIAR Bulletin No. 116 *Guidelines for: Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock.*
This standard revision is intended to be a single source for the minimum requirements for ITM tasks for safe closed-circuit ammonia refrigeration systems. This standard revision is not intended to detail the means or methods of ITM except where specifically noted herein. Other organizations have historically provided

guidelines for ITM and this standard is not intended to replace their guidance, but instead establish what ammonia refrigeration system components shall be inspected, tested, and maintained and the frequency of these tasks. This standard revision also provides the minimum requirements for the record keeping responsibilities of ITM.

ITM shall be executed in a safe manner and in accordance with all applicable regulations.

Informative Appendix A ***was added to provide explanatory material related to provisions in the standard.*** *Sections of the standard with associated explanatory information are marked as 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 standard revision, the IIAR Standards Committee included the following members:

Don Faust, Chair - Johnson Controls
Mark Bazis, Jr., Vice Chair - Refrigeration Consultants
Jake Denison - EVAPCO, Inc.
Anthony Frosos - Wayne-Sanderson Farms
Brian McMillan - Intercool USA
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Lesley Schafer - C&S Wholesale Grocers
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Brian Alleman - Leprino Foods – Term starts after March 23rd, 2024 SC Meeting
Danny Halel - Nthalp Engineering– Term starts after March 23rd, 2024 SC Meeting
John Collins - Zero Zone– Term starts after March 23rd, 2024 SC Meeting
Susan Kelley - Linde– Term starts after March 23rd, 2024 SC Meeting
Eric Smith - IIAR Staff
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The subcommittee responsible for writing this standard had the following members at the time of publication:

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Contents

Part 1 General

Chapter 1. Purpose, Scope, and Applicability

1.1 *Purpose.

This standard specifies minimum requirements for inspection, testing, and maintenance for closed-circuit ammonia refrigeration systems.

1.2 *Scope.

Record keeping, inspection, testing, and maintenance of closed-circuit ammonia refrigeration systems and ancillary equipment shall comply with this standard. This standard addresses equipment that is common to stationary closed-circuit ammonia refrigeration systems. Due to variations in system design and installation criteria, some systems will not include each type of equipment addressed by this standard.

1.3 Applicability.

This standard applies to closed-circuit ammonia refrigeration systems.

1.3.1

This standard shall not apply to startup or decommissioning of ammonia refrigeration systems, system components, or ancillary equipment.

1.3.2

This standard shall not apply to portable refrigeration systems that are listed and manufactured in accordance with other ANSI standards.

1.3.3

This standard shall not apply to absorption or adsorption systems containing 22 lbs. (10 kg) or less.

1.4 Conflicts.

Where a conflict exists between this standard and the Building Code, Fire Code, Mechanical Code, Plumbing Code, Electrical Code, or any Federal or state law or rule, the requirements of these codes shall take precedence over this standard unless otherwise stated in such code, law, or rule.

1.4.1 Alternative Materials and Methods.

Where approved by the authority having jurisdiction (AHJ), the use of devices, materials, or methods not prescribed by this standard is permissible as an alternative means of compliance, provided that any such alternative has been documented and shown to be equivalent in quality, strength, effectiveness, durability, and safety.

1.4.2 Installations in Locations Without an Authority Having Jurisdiction (AHJ).

Where a system is installed in a jurisdiction without an AHJ, facility management is authorized to specify an alternative to the requirements of this standard, and the alternative shall be documented in the facility records.

Chapter 2. Definitions

2.1 General.

Definitions shall be in accordance with this chapter and ANSI/IIAR 1.

2.2 *Defined Terms.

The following words and terms, which are used in this standard, shall be defined as specified in this chapter.

automatic record keeping: The collection of operating conditions without the use of a trained operator.

emergency shut-off valve: A shut-off valve that has been specifically identified for equipment or system emergency shutdown, mitigation of an emergency, or both.

deficiency: For purposes of inspection, testing, and maintenance of refrigeration systems, a condition with the potential to result in or prolong a refrigerant release.

documentation: Data that provides information, official confirmation, evidence, or a combination thereof that can serve as a record.

frequency: The interval rate that inspections, testing, and maintenance (ITM) tasks are performed on a calendar basis.

heat exchanger: Equipment that uses heat transfer surfaces such as coils constructed of pipes or tubes placed inside a shell or paired plates that are welded or brazed together or elastomerically sealed that may be placed inside a shell or stacked between pressure end-plates.

inspection: The evaluation and assessment of equipment, a component, a system, or a portion of a system using human senses such as vision, hearing, touch, smell, or a combination thereof.

installed: The condition under which a device, a component, or equipment is currently physically or wirelessly connected to any portion of the refrigeration system or an ancillary safety system.

ITM: Abbreviation of inspection, testing, and maintenance.

maintenance: Work performed to prolong safe operation of equipment, components and devices.

manufacturer: An entity, enterprise, or organization that makes a product or products for sale through a process or processes involving raw materials, components, or assemblies, usually on a large scale.

nondestructive testing (NDT): Test methods used to examine an object, material, or system without causing damage.

operating limits: Defined upper or lower operating control limits which are the extent of the defined operating range within the safe design limits of the equipment or system.

predictive maintenance: Work performed to reduce the probability of unexpected equipment or component failure.

qualified inspector: A person who is experienced with the specific refrigerant in a closed-circuit refrigeration system, has knowledge of the process, and has demonstrated proficiency and understanding to perform inspections.

RAGAGEP: Acronym for recognized and generally accepted good engineering practices, which are the basis for engineering; operation; or inspection, testing, and maintenance activities and are themselves based on established codes, consensus standards, non-consensus documents, recommended practices (RP), or other similar industry-related documents including corporate internal standards..

record keeping: The storage of documentation recording periodic inspections, tests, servicing, and other operations and maintenance.

secondary coolant: Any liquid used for the transmission of heat without a change in its state. Examples of secondary coolants include glycol and brine.

sudden liquid deceleration: The rapid decrease of liquid flow in a line or pipe, for example due to the sudden closing of a valve. This is also referred to as hydraulic shock or liquid hammer.

support: Any load bearing structure, such as steel, concrete, anchor bolts, ceiling, roof and building structure, that bears the expected static and dynamic loads, such as refrigerant charge, frost, snow, seismic, wind, thermal expansion and equipment vibration.

test: The operation of equipment, a component, or a device to verify that it is functioning correctly, or the measurement of a system characteristic to determine if it meets requirements.

testing: A procedure used to determine the operational status of equipment, a component, a device, or a system by conducting periodic functional checks.

vapor propelled liquid: The high-velocity movement of liquid refrigerant propelled by high-pressure vapor in hot gas or suction lines due to high or excessive differential pressure. This is also referred to as hydraulic shock, liquid hammer, or surge.

Chapter 3. Reference Standards

3.1 **American Society of Mechanical Engineers (ASME).**

Standards as follows:

1. ASME B&PVC-2023, *Boiler and Pressure Vessel Code, Pressure Vessel, Section VIII, Division 1*.

3.2 **International Institute of All-Natural Refrigeration (IIAR).**

Standards as follows:

1. ANSI/IIAR 1-2022, *Definitions and Terminology Used in IIAR Standards*.
2. ANSI/IIAR 2-2021, *Standard for Design of Safe Closed-Circuit Ammonia Refrigeration Systems.*
3. ANSI/IIAR 3-2022, *Ammonia Refrigeration Valves*.
4. ANSI/IIAR 4-2020, *Installation of Closed-Circuit Ammonia Refrigeration Systems*.
5. ANSI/IIAR 5-202x, *Startup of Closed-Circuit Ammonia Refrigeration Systems.*
6. ANSI/IIAR 8-2020, *Decommissioning of Closed-Circuit Ammonia Refrigeration Systems.*

3.3 **International Safety Equipment Association (ISEA).**

Standard as follows:

1. ANSI/ISEA Z358.1-2014 (R2020), *World Safety Standard for Emergency Eyewash and Shower Equipment*.

Chapter 4. Program Administration

4.1 Management Responsibilities.

4.1.1 Responsibility of Compliance.

The owner or owner's designated representative shall be responsible for overseeing and ensuring that inspection, testing, and maintenance is performed in accordance with the requirements of this standard.

4.1.2 Owner's Designated Representative.

The owner's designated representative shall be responsible for ensuring necessary actions to maintain compliance with record keeping, inspection, testing, and maintenance requirements of this standard. Action item lists for inspection, testing, and maintenance shall be developed and maintained by the owner's designated representative, who shall be responsible for completing or overseeing the completion of the action items in a timely manner.

4.1.3 Compliance Schedule.

An owner shall be in compliance with this standard when it is adopted by the authority having jurisdiction (AHJ) or when it is adopted by the owner, whichever is first.

Part 2 Requirements

Chapter 5. General

5.1 *ITM Program Requirements.

The owner or owner's designated representative shall ensure an inspection, testing, and maintenance program is developed to reduce the probability of an ammonia release. This program shall comply with manufacturer recommendations, equipment and system operating and maintenance history, and the minimum safe requirements of this standard.

When performing ITM tasks, safe work practices shall be used.

5.1.1 Inspection and Testing.

Inspections and tests shall be performed on the ammonia refrigeration systems, equipment, and devices.

5.1.1.1

*The frequency of inspection and testing shall be consistent with applicable manufacturers' recommendations and operating history.

5.1.1.2

Inspection and testing procedures shall follow recognized and generally accepted good engineering practices (RAGAGEP).

5.1.1.3

*Each inspection and test performed shall be documented and include the following information:

1. Date of the inspection or test;
2. Name of the individual or individuals that performed the inspection or test;
3. Serial number or other identifier of the equipment on which the inspection or test was performed;
4. Description of the inspection or test performed, including expected results;
5. Results of the inspection or test.

5.1.1.4

*Deficiencies identified during inspection and testing shall require the development of a documented method to address each action item related to ensuring safe operations.

5.1.1.4.1

*Deficiencies addressed and corrected immediately during inspection and testing are not required to be tracked on this documented method.

5.1.2 Equipment Deficiencies.

Equipment identified as operating outside of the operating limits shall be corrected before further use or in a safe and timely manner when necessary means are taken to ensure safe operation.

5.1.2.1

Equipment shall not be set to operate outside of upper and lower safe operating limits.

5.1.3 Maintenance.

Equipment shall be maintained to operate within operating limits.

5.1.3.1
Maintenance procedures shall follow RAGAGEP.

5.1.3.2
*Maintenance frequencies shall be in accordance with Section 5.6.4.

5.1.4 ***Materials and Replacement Parts.**
Maintenance materials and replacement parts shall be suitable for the system application for which they will be used.

5.1.5 ***Risk-Based ITM.**
Risk-Based ITM strategies for performing inspection, testing, and maintenance tasks and evaluating frequencies are permitted.

5.2 ***Frequency.**
Inspection, testing, and maintenance shall be performed at frequencies occurring within the Calendar Basis in lieu of Runtime Basis (hours) as outlined in Table 5.2.

Table 5.2
Frequencies

Period	Calendar Basis	Runtime Basis (hours)
Daily	Occurring once per 24 hours.	24
Weekly	Occurring once per calendar week.	168
Monthly	Occurring once per calendar month.	730
Quarterly	Occurring four times per year. The minimum period between ITM tasks is 2 months. The maximum is 4 months.	2,190
Semiannual	Occurring twice per 12 consecutive months. The minimum period between ITM tasks is 4 months. The maximum is 8 months.	4,380
Annual	Occurring once per year. The minimum period between ITM tasks is 9 months. The maximum is 15 months.	8,760
Biennial (Two Years)	Occurring once every other year. The minimum period between ITM tasks is 21 months. The maximum is 27 months.	17,520
Three Years	Occurring once every 36 months. The minimum period between ITM tasks is 30 months. The maximum is 42 months.	26,280
Five Years	Occurring once every 60 months. The minimum period between ITM tasks is 54 months. The maximum is 66 months.	43,800
Ten Years	Occurring once every 120 months. The minimum period between ITM tasks is 108 months. The maximum is 132 months.	87,600

5.2.1
*Where a history of deficiencies has been recorded, the ITM task frequencies shall be increased. Where a history of fault-free operation has been recorded, the ITM task frequencies are permitted to be

decreased. In either case, a determined change in an ITM task frequency and its technical justification shall be documented.

5.2.2

*A frequency of “WA - Where Applicable” and its designated period for the frequency applies to equipment that has the option or feature.

5.3 *Record Keeping Requirements.

The owner or owner’s designated representative shall ensure a record keeping program is established and maintained to provide evidence that the provisions of this standard have been implemented and to address identified deficiencies.

5.3.1

*The owner or owner’s designated representative shall perform the record keeping activities. An automatic record keeping system that meets these requirements is permitted. Records shall be reviewed not less than once per week to identify safety alarms, shutdowns, system functioning near or outside operating limits, or a combination thereof. Corrective action for identified safety items shall be developed and implemented.

5.3.2

*Inspection, testing and maintenance records shall be readily accessible, whether filed at the facility, offsite, or electronically.

5.3.3

*The current system documentation records shall be readily accessible and include the following:

1. Refrigeration flow drawings;
2. Defined operating limits;
3. Safety system functional description;
4. Relief valve list with pressure relief valve (PRV) manufacturer, PRV model number and set pressure, and where applicable the three-way valve manufacturer and model number;
5. Ventilation system equipment list, specifications and functional description.
6. Installation, operation, and maintenance manuals;
7. Manufacturer data reports for all pressure vessels;
8. Equipment list.

5.3.4 *Monitored Control.

Where a monitored control is utilized, operating parameters being acquired automatically as the system is being used in lieu of performed rounds shall be verified and alarm messages shall be tested per this standard’s frequencies to ensure notifications are sent and received.

5.3.5

Lack of functional instrumentation does not reduce record keeping requirements.

5.3.6 Refrigeration System Records.

The following refrigeration system records shall be maintained:

5.3.6.1

*A means of record keeping, such as a log, to document and transfer pertinent operational, maintenance, and ongoing duty information between operators shall be implemented.

5.3.6.2
Secondary coolant records shall include the type of fluid, equipment identification, equipment location, quantity added or removed, and the date. Other fluid information necessary for the process shall also be included, such as pH or the solution composition.

5.3.6.2.1
For secondary coolants which contain a component with a freezing point equal to or greater than the saturation temperature of the corresponding refrigeration system, the freeze point or specific gravity of each independent secondary coolant circuit shall be measured and recorded prior to charging and after charging to determine if the secondary coolant concentration is within the operating limits.

5.3.6.3
Ammonia refrigerant records for contamination shall include the location where the sample was taken, the sample size, the color of the impurity residue, the contamination measured, the percent of the concentration of contamination, and the date.

5.3.6.4
*Refrigeration oil records for documenting the type of oil, the total estimated amount of oil in the system, the quantity added or removed, the location where the oil was added or removed, and the date.

5.3.6.4.1
Annually, a comparison between the oil drained and added shall be estimated as the net change of oil in the system.

5.3.6.5
*Lubrication records shall include the type of lubrication, the quantity of lubrication required, and the amount of lubrication added.

5.3.6.6
*Pressure relief valve records shall include the pressure relief device identification, equipment identification that it is installed on, the set pressure, and the date of installation.

5.3.7 ***Retention of Records.**
Records shall be retained in accordance with Table 5.3.7 or per a facility’s requirements that take precedence to sustain processing, jurisdictional regulatory requirements, or both, such as for food safety.

Table 5.3.7
Retention of Records

Type of Record	Retention Duration
Daily Inspection Records	Most current 12 months
Daily Testing Records	Most current 12 months
Daily Maintenance Records	Most current 12 months
Weekly Inspection Records	Most current 52 weeks
Weekly Testing Records	Most current 52 weeks
Weekly Maintenance Records	Most current 52 weeks
Monthly Inspection Records	Most current 24 months

Monthly Testing Records	Most current 24 months
Monthly Maintenance Records	Most current 24 months
Quarterly Inspection Records	Most current 8 quarters
Quarterly Testing Records	Most current 8 quarters
Quarterly Maintenance Records	Most current 8 quarters
Semiannual Inspection Records	Most current 2 years
Semiannual Testing Records	Most current 2 years
Semiannual Maintenance Records	Most current 2 years
Annual Inspection Records	Most current 5 years
Annual Testing Records	Most current 5 years
Annual Maintenance Records	Most current 5 years
Three Year Inspection Records	Two (2) most current
Three Year Testing Records	Two (2) most current
Three Year Maintenance Records	Two (2) most current
Five Year Inspection Records	Two (2) most current
Five Year Testing Records	Two (2) most current
Five Year Maintenance Records	Two (2) most current
Ten Year Maintenance Records	Two (2) most current
Engineering design documentation	Life of the process
Pressure vessel U1, U-1A, U-3, UM reports	Equipment life
Log (Operator Transfer of Information)	Most current 12 months
Secondary Coolant Records	Most current 12 months
Ammonia Refrigerant Records	Most current 5 years
Refrigeration Oil Records	Most current 5 years
Lubrication Records	Most current 5 years
Pressure Relief Valve Records	PRV life
Current System Records listed in Section 5.3.3	Life of the process
Instrument and device testing and calibration	Most current 5 years

5.4 Inspection Requirements.

The owner or owner's designated representative shall ensure an inspection program is developed and maintained to meet the requirements of Sections 5.1 – 5.3 and this section.

5.4.1

*When a deficiency is identified, the owner or owner's designated representative shall ensure a timely evaluation is arranged to determine the appropriate corrective action(s) and the time frame to execute each task.

5.4.2

*Equipment inspections shall be performed by a Qualified Inspector(s). Every fifth (5th) year, at a minimum, the annual inspections in the normative Chapters of IIAR 6, not including testing and maintenance tasks, shall be conducted by a qualified inspector who shall not be influenced by the facility's record keeping, operations, maintenance, or management. This person shall not present a conflict of interest and shall report instances of deficiencies.

5.4.2.1

***** During the fifth-year inspection, if operational, or scheduling constraints prevent any annual inspection tasks from being performed by the fifth-year inspector(s), they shall be performed by a qualified inspector(s) of the facility's choosing. The fifth-year qualified inspector shall review the facility inspection records to ensure that those tasks are being performed on an annual basis.

5.5 **Testing Requirements.**

The owner or owner's designated representative shall ensure a testing program is established and maintained to meet the requirements of Sections 5.1 – 5.3 and this section.

5.5.1

*The testing program requirements shall be implemented to verify that safety equipment and associated control circuits are calibrated and will function as intended, particularly in the case of protection devices and associated control circuits used for shutting down refrigeration equipment and/or safety systems.

5.5.2

*Testing instruments, testing devices, and testing gauges used for testing refrigeration system protection devices shall be calibrated in accordance with manufacturers' instructions.

5.5.2.1

Pressure and temperature measurement testing devices shall be verified for accuracy and calibrated to master gauges or a dead weight tester, with calibration records retained stating that the testing devices calibration has not expired.

5.5.3

*Testing and calibration of protection devices that are integral to the function of shutting down equipment or systems to reduce the probability of an ammonia release, where the devices are designed and installed for such and within design limits, shall be in accordance with manufacturers' instructions but tested and calibrated not less than once per year to verify the intended equipment or system shuts down.

5.5.4

*Portions of the system opened to the atmosphere for inspection testing and maintenance shall be checked for leaks after applicable ITM tasks are complete and prior to resuming normal operations.

5.5.4.1

Leak test pressures for leak testing after routine maintenance activities that do not involve a weld repair, a modification, or an expansion of the closed-circuit system may use the design operating pressure.

5.5.4.1.1

For positive pressure parts of the closed-circuit system, using the system operating pressure is sufficient for leak testing.

*5.5.4.1.2

For parts of the closed-circuit system that operate in a vacuum, the test should be performed at the greater of 10 psig or the highest pressure that the tested part of the closed-circuit system will have during a normal operational cycle, which may include defrost cycles, standby (off cycle), or other conditions.

5.5.4.2

System refrigerant or other inert gasses shall be used for the leak test media to verify the seals and flanged connections that were separated for repairs.

5.5.5
*Where standby power sources are installed for emergency systems, these power sources shall be tested per the manufacturer's instructions or not less than once per year, whichever is more frequent.

5.5.6
Test frequencies shall be in accordance with manufacturers' recommendations, historical ITM data, predictive maintenance reports, and other adopted RAGAGEP.

5.6 Maintenance Requirements.

The owner or owner's designated representative shall ensure a maintenance program is developed and maintained to meet the requirements of Sections 5.1 – 5.3 and this section.

5.6.1
*Procedures shall be developed for maintenance tasks and used where applicable. Applicable procedures include safe work practices.

5.6.2
*A non-routine maintenance task shall require a safe procedure be developed prior to the task being performed.

5.6.3
*Maintenance using an open flame, arc welding, or other hot work requires a hot work procedure, hot work permit, or both to reduce the risk of fire or explosion.

5.6.3.1
*Safely applying heat to a system component to evaporate residual liquid ammonia is permitted providing the area is confirmed free of combustibles and flammables.

5.6.3.2
Portable tools having open flames are permitted to be used to assist the migration of liquid refrigerant within the closed-circuit system. Such tools shall not be capable of cutting or reducing mechanical integrity of portions of the system to which they are applied.

5.6.3.3
Isolated equipment containing liquid ammonia shall not be intentionally heated.

5.6.3.4
The use of matches, lighters, sulfur sticks, welding equipment, and similar portable devices shall be permitted except while ammonia charging, transferring, or removal is being performed, while oil draining or charging is being performed, and/or while the ammonia concentration is greater than 150 ppm.

5.6.3.5
Compressor oil is permitted to be stored in machinery rooms outside of fire rated cabinets so long as the containers or barrels do not obstruct the pathways to eyewash & safety showers and do not obstruct emergency egress routes.

5.6.4
Maintenance frequencies shall be in accordance with the maintenance tasks located in the equipment chapter ITM task tables, based from manufacturers' recommendations, historical ITM data, predictive maintenance reports, or a combination thereof.

5.6.5
*When valves are exercised, an ammonia compatible lubricant shall be applied to protect an exposed direct acting stem and stem sealing components from corrosion.

5.6.5.1
*Isolation valves shall be operated in accordance with manufacturers' instructions.

5.6.5.2
Operation of isolation valves shall not cause sudden liquid deceleration, trapped liquid, or create a vapor propelled liquid surge.

5.6.6
*If system alarms will activate during controlled maintenance tasks or inspections, disabling alarms through engineering or administrative controls, or both, shall be permitted as a means of controlling and preventing nuisance alarms. The affected alarms shall be restored to service and verified operational by bump testing functionally tested after the controlled maintenance tasks or inspections are complete (Refer to Section 12.3).

5.6.7
Already set mechanically expanded concrete anchor bodies shall not be adjusted or axially spun.

5.6.8
*Equipment and piping shall be kept free from excessive ice buildup.

5.6.8.1
Ice buildup shall not interfere with the proper operation of emergency shut-off valves.

5.6.8.2
Ice accumulation shall not be permitted to bend pipes, displace components, or negatively impact the system's structural integrity.

5.6.9
Installation of equipment, where replacement of equipment is determined as the recommended corrective action for maintenance, shall be in accordance with ANSI/IIAR 4.

5.6.10
Startup of equipment and systems following maintenance shall be in accordance with ANSI/IIAR 5.

5.6.11 ***Out-of-Service.**

5.6.11.1
Where refrigerant has been removed from refrigerant containing equipment, the ITM Tasks for that equipment are permitted to be deferred in accordance with this section. ITM tasks shall be addressed and a pre-startup safety review (PSSR) performed before placing the equipment back into service**.**

5.6.11.2
ITM Tasks described in Table 12.1 - 12.5 shall not be deferred when any portion of the refrigeration system protected by one or more of those safety systems remains charged with refrigerant.

5.6.11.3
Equipment for which ITM tasks are deferred shall be locked out, tagged “Out of Service”, and disabled from operation.

5.6.11.4
*The pressure of equipment isolated from a system that remains charged with refrigerant shall be verified at least monthly to ensure that refrigerant has not migrated back into the equipment.

5.6.11.5
ITM Tasks that were deferred while the equipment was out of service shall be completed for one of each frequency in Table 5.2 prior to the equipment being placed back into service. Only the most recent iteration of the deferred ITM Tasks is required to be performed.

5.6.11.6
When a refrigeration system has been tagged “Out of Service” for more than five (5) years with no startup date on the horizon, the refrigerant shall be removed from the system. ITM Tasks may be deferred, including those described in Table 12.1 - 12.5.

Chapter 6. Compressors

6.1 ***Inspection, Testing, and Maintenance Tasks**. Inspection, testing, and maintenance tasks shall be performed on the different compressor types at the indicated frequencies, set forth in Table 6.1.

TABLE 6.1
Compressor Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency		
Inspection	**Screw**	**Reciprocating**	**Rotary Vane**
a) Runtime hours	WA-D	WA-D	WA-D
b) Suction pressure	D	D	D
c) Discharge pressure	D	D	D
d) Oil pressure	D	D	D
e) Oil temperature	D	WA-D	D
f) Discharge temperature	D	D	D
g) Verify oil levels are adequate	D	D	D
h) Oil filter differential pressure	D	WA-D	NA
i) Oil leaks	D	D	D
j) Lubricator oil level and drip rate	NA	NA	D
k) Jacket cooling oil level	NA	NA	D
l) Determine shaft seal leak rate	WA-W	WA-W	WA-W
m) Indicator of Compressor Capacity	WA-D	WA-D	WA-D
n) Motor amperage (current)	D	WA-D	WA-D
o) Recorded Alarms and Shutdowns	D	WA-D	WA-D
p) Free from abnormal sounds and excessive vibration	D	D	D
q) Drive guard in place and secure	D	D	D
r) Foundation solid, in place, and free from evidence of deterioration	A	A	A
s) Visually inspect mounting bolts are in place	A	A	A
t) Free from pitting or surface damage	A	A	A
u) Visually inspect coupling for wear	A	WA-A	WA-A
v) Visually inspect starter connections and associated timers and relays	A	A	A
w) Operation of oil heaters	A	A	A

x) Operation of unloader	M	M	M
y) Visually inspect alignment of compressor-motor drive shaft	A	A	A
Testing			
Test safety shutdowns:			
a) Low suction pressure cutout	A	A	A
b) High discharge pressure cutout (HPCO) See Section 6.1.1	A	A	A
c) High discharge temperature cutout	A	WA-A	A
d) Low oil pressure cutout	A	A	A
e) High liquid level cutout	A	A	A
Maintenance			
a) Add Oil	As Needed	As Needed	As Needed
b) Change oil filter	As indicated by oil filter ΔP, runtime hours, or oil analysis	As indicated by oil filter ΔP, runtime hours, oil analysis, or A	As indicated by oil filter ΔP, runtime hours, or oil analysis
c) Clean external oil pump suction strainer	WA-5	NA	NA
d) Oil Analysis - Take oil sample and obtain oil analysis results from qualified testing lab [Not required if oil is changed on an Annual (A) frequency or a determined runtime hours frequency]	S or runtime hours	S or runtime hours	S or runtime hours
e) Align external oil pump shaft	WA-5	WA-5	WA-5
f) Change oil	As indicated by oil analysis or predetermined runtime	As indicated by oil analysis, predetermined runtime, or A	As indicated by oil analysis or predetermined runtime
g) Verify coupling bolts are in place	A	A	A
h) Replace shaft seal	When maximum pre-determined leak rate is approaching or reached	When maximum pre-determined leak rate is approaching or reached	When maximum pre-determined leak rate is approaching or reached
i) Align compressor-motor drive shaft	When maximum pre-determined alignment parameters are exceeded	When maximum pre-determined alignment parameters are exceeded	When maximum pre-determined alignment parameters are exceeded
j) Lubricate motor bearings	WA-S	WA-S	WA-S

k) Remove electrical connection box cover and visually inspect insulation on motor leads	A	A	A
l) Verify integrity of power supply and control circuit electrical connections	A	A	A
m) Verify integrity of starter connections and associated timers and relays	A	A	A
n) Calibrate pressure and temperature devices (found in the Testing Section above)	A	A	A
o) Inspect for rotor axial play in driven rotor shaft	A	A	NA
p) Inspect pistons, rings, and plate valves	NA	WA-5 or pre-determined runtime hours	NA
q) Inspect vanes	NA	NA	5
r) Verify belt tension by measurement and its condition	NA	S	S
s) Verify pulley hub conditions	NA	A	A
t) Check electrical wiring and connections for hot spots	A	A	A
u) Calibrate motor current transducer/transformer	A	WA-A	NA
v) Calibrate capacity/volume (slide valve) controls	A	NA	NA

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

6.1.1
*The compressor cutout devices and associated control circuits shall be tested and calibrated in accordance with Section 5.5.

6.1.2
The High Liquid Level cutout devices and shutdown circuits shall be tested such that if a high liquid level in a vessel could result in the carryover of liquid refrigerant to compressors, those associated compressors will shut down or be prevented from operating.

6.1.2.1
High Liquid Level cutout devices and shutdown circuits shall be tested by raising the liquid level in the device to activate the high liquid level shutdown, while taking care to prevent vessel overfilling or causing carryover of liquid refrigerant to associated compressors.

6.1.3
*To avoid operational disruption by repeated compressor shutdowns, and where there is only one compressor shutdown control circuit utilized by all of the safety cutouts, it is permissible to test one of the cutouts, such as the low suction pressure cutout, to verify the control circuit actually shuts down the compressor. The remaining

cutout tests for that compressor can be verified by activation of the compressor's cutout and verifying the compressor does not start.

6.1.4
The function of the high discharge pressure shutdown safety device to shut down the compressor shall be tested by one of the following methods based on the type of device being used:

6.1.4.1 ***Electromechanical Pressure Sensor.**
Functional testing of an electro-mechanical pressure sensor as a high-pressure limiting device requires proof of the three following characteristics:

1. Function of the device to shut down an operating compressor.
2. Function test setpoint shall be no more than 90% of the relief valve setting.
3. Calibration of the device to show it functions within an accuracy of +/- 2.5% at the setpoint when compared to a pressure standard or master gauge.

6.1.4.1.1 **Permitted Test Methods:**

1. Manipulation of discharge pressure to the cutout set point.
2. Using a check valve, a bleed valve, and an external pressure source.

6.1.4.1.2 **Prohibited Test Methods:**

1. Removal and bench testing of the electromechanical pressure sensor.
2. Isolation of a shutdown compressor, followed by pressurization.
3. Reduce the cut-out set point.

6.1.4.2 ***Pressure Transducer or Transmitter Connected to an Electronic Controller.**
Functional testing of a pressure transducer or transmitter connected to an electronic controller as a pressure-limiting device requires proof of the three following characteristics:

1. Function of the device to shut down an operating compressor after sensors are calibrated.
2. Setpoint shall be no more than 90% of the relief valve setting.
3. Calibration of the device to show it reads pressure within an accuracy of +/- 2.5% at the set point or at two pressures chosen to verify the accuracy of the calibration curve programmed into the controls, when compared to a pressure standard or master gauge.

6.1.4.2.1 **Permitted Test Methods:**

1. Manipulation of discharge pressure to the cutout set point.
2. Reduce the cutout set point and raise the discharge pressure until shutdown occurs.
3. Using a check valve, a bleed valve, and an external pressure source.

6.1.4.2.2 **Prohibited Test Methods:**

1. Removal and bench testing of the pressure transducer or transmitter.
2. Isolation of a shutdown compressor, followed by pressurization.

Chapter 7. Refrigerant Pumps

7.1 ***Inspection, Testing, and Maintenance Tasks**. Inspection, testing, and maintenance tasks shall be performed on refrigerant pumps at the indicated frequencies, set forth in Table 7.1.

TABLE 7.1
Refrigerant Pumps Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency	
Inspection	**Low Probability**	**Open Drive**
a) Verify pump discharge pressure is acceptable	W	W
b) Verify guards are in place and secure	WA-W	W
c) Listen for abnormal sounds	W	W
d) Visually inspect for excessive vibration	W	W
e) Verify oil level in reservoir is acceptable	NA	W
f) Visually inspect motor power circuit electrical connections	A	A
g) Visually inspect control circuit electrical connections	A	A
h) Visually inspect pump assembly for oil leaks and connective tubing for integrity	WA-D	D
i) Visually inspect pump bearing wear monitor	WA-W	WA-W
j) Visually inspect pump metal surface for pitting or surface damage	A	A
Testing		
a) Verify operation of refrigerant pump oil heater	NA	WA-M
b) Cavitation cutout	WA-A	WA-A
Test safety shutdowns:		
c) Low liquid level cutout	A	A
d) Low oil level cutout	NA	A
Maintenance		
a) Verify base frame anchors are in place and secure	A	A
b) Verify belt tension by measurement and its condition	NA	WA-S

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

Chapter 8. Condensers

8.1 ***Inspection, Testing, and Maintenance Tasks**. Inspection, testing, and maintenance tasks shall be performed on condensers at the indicated frequencies, set forth in Table 8.1. This includes highside heat exchangers. For heat exchangers that are pressure vessels, see Chapter 10.

TABLE 8.1
Condensers Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency			
Inspection	**Evaporative**	**Shell-and-Tube**	**Plate-Heat Exchanger**	**Air-Cooled &** Adiabatic
a) Visually inspect water spray pattern from nozzles for sufficient water distribution	S	NA	NA	NA
b) Visually inspect mist eliminators for condition and water carryover	S	NA	NA	NA
c) Visually inspect condenser coils for degradation of the coating and that there is no accumulation of scale or algae growth	A	NA	NA	A
d) Visually inspect the exterior edges of exposed installed gaskets for degradation or indications of leakage at shell heads and plates	NA	WA-A	WA-A	NA
e) Verify condenser fans, shrouds, and hubs are in place and have no signs of cracking or excessive degradation, including no obstructions	Q	NA	NA	Q
f) Listen to rotating parts for abnormal sounds	W	NA	NA	W
g) Visually inspect rotating parts for excessive vibrations	W	NA	NA	W
h) Visually inspect the condition and alignment positioning of couplings and pulleys	WA-A	NA	NA	WA-A
i) Verify guards of moving parts are in place and secure	W	NA	NA	W
j) Verify adequate oil level in gear box	WA-A	NA	NA	WA-A
k) Visually inspect supports are in place	A	A	A	A
l) Verify water supply is functional Expected Result: Observe that the water level is at the design operating level.	W	WA-W	WA-W	NA
m) Verify secondary coolant circulation	NA	WA-W	WA-W	NA
n) Verify motor mounting bolts are in place	A	A	A	A
o) Visually inspect adiabatic pad is not limiting air flow	NA	NA	NA	Q
Testing				
a) Verify water treatment program is within tolerance	WA-M	NA	NA	NA

b) Test tubes with pressure for integrity and leakage	NA	5 or As Needed	NA	NA
Maintenance				
a) Verify belt tension by measurement and its condition	WA-S	NA	NA	WA-S
b) Lubricate fan shaft bearings	Q	NA	NA	Q
c) Access and verify condition of fan blade hubs	Q	NA	NA	Q
d) Clean water sump and sump strainer(s)	A	NA	NA	NA

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

Chapter 9. Evaporators

9.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on evaporators at the indicated frequencies, set forth in Table 9.1. This includes lowside heat exchangers. For heat exchangers that are pressure vessels, see Chapter 10.

TABLE 9.1
Evaporators Inspection, Testing, and Maintenance Tasks

ITM Task Description	**Frequency**									
Inspection	Forced- Air	Shell-and-Tube	Plate & Frame	Shell & Plate	Scraped (Swept) Surface	Jacketed Tank Crystallizer Tank	Ice Builder	Bunker Coil	Make-up Air/Make-up Hygienic With Heat	Falling Film
a) Listen to rotating parts for abnormal sounds	W	WA-W	WA-W	NA	W	WA-W	WA-W	NA	W	WA-W
b) Observe for excessive vibration	W	WA-W	WA-W	WA-W	W	WA-W	WA-W	WA-W	W	WA-W
c) Visually inspect the supports, fasteners, and mounting bolts for cracking, warping, stretching, bending, and looseness	A	A	A	A	A	A	A	A	A	A
d) Inspect external parts for damage	S	S	S	S	S	S	S	S	S	S
e) Verify fan guards are in position and have no obstructions	WA-M	NA	NA	NA	NA	NA	WA-S	NA	WA-M	NA

f) Visually inspect fan blade hubs for cracking	S	NA	NA	NA	NA	NA	WA-S	NA	A	NA
g) Verify evaporator is free from excessive ice buildup	M	NA	WA-M	NA	NA	NA	M	W	W	W
h) Inspect evaporator for dirt buildup	S	NA	NA	NA	NA	NA	S	S	S	S
i) Verify protection against traffic is in place	A	A	A	A	A	A	A	A	NA	A
j) Inspect filters	NA	NA	NA	NA	NA	NA	NA	NA	W	NA
k) Inspect burner flame	NA	NA	NA	NA	NA	NA	NA	NA	WA-W	NA
l) Inspect damper linkage	NA	NA	NA	NA	NA	NA	NA	NA	M	NA
m) Verify the pressure drop differential across the air filters is in range	NA	NA	NA	NA	NA	NA	NA	NA	WA-S	NA
n) Verify secondary coolant circulation	NA	WA-A	WA-A	A	NA	WA-A	A	NA	NA	M
o) Verify air volume flow	NA	NA	NA	NA	NA	NA	NA	NA	WA-D	NA
p) Visually inspect drain pan to ensure it is free of obstructions	S	NA	NA	NA	NA	NA	NA	WA-S	A	S
Testing										
a) Observe defrost cycle	WA-A	WA-3	WA-3	NA	WA-3	WA-3	NA	WA-A	WA-A	WA-3
b) Verify fan belt tension by measurement	WA-M	NA	NA	NA	NA	NA	WA-S	NA	WA-M	NA

and its condition										
c) Functionally test ammonia detector Expected Result: Verify alarming devices and sequences when activated with exposure to ammonia.	NA	NA	NA	NA	NA	NA	WA-A	WA-A	WA-A	NA
d) Functionally test smoke detector Expected Result: Verify that evaporators perform the sequence of operations when the manufacturer recommended test is performed.	NA	NA	NA	NA	NA	NA	NA	NA	WA-S	NA
e) Functionally test burner safety controls Expected Result: Verify That evaporators perform the sequence of operations when the manufacturer recommended test is performed.	NA	NA	NA	NA	NA	NA	NA	NA	WA-S	NA
Maintenance										NA
a) Clean unit to remove visible dirt	WA-A	WA-5	WA-A	WA-A	WA-A	WA-S	WA-S	WA-S	WA-S	WA-S

b) Calibrate ammonia detector	WA-S	WA-S	WA-S	WA-S	WA-S	WA-S	WA-S	WA-S	WA-S	WA-S
c) Lubricate fan shaft bearings	WA-S	NA	NA	NA	NA	NA	WA-S	NA	WA-S	NA
d) Lubricate motor bearings	WA-3	NA	NA	NA	WA-3	WA-3	WA-3	NA	WA-3	WA-3

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR – Not Required, Others as noted.

Chapter 10. Pressure Vessels

10.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on carbon steel pressure vessels at the indicated frequencies, set forth in Table 10.1.

TABLE 10.1
Pressure Vessels Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency	
Inspection	Insulated	Non-Insulated
a) Visually inspect metal surfaces for pitting or surface damage	NA	A
b) Visually inspect nozzle connections for pitting or surface damage	NA	A
c) Visually inspect sight glass metal surfaces for pitting or surface damage	WA-A	WA-A
d) Visually inspect for damage and/or moisture in insulation (i.e., dampness, condensation, frost, ice buildup)	A	NA
e) Visually inspect for indications of degradation of the protective coating (i.e., vent)	NA	A
f) Visually inspect foundation for cracking and oversettling	A	A
g) Visually inspect anchors for cracking or damage (i.e., bolts, nuts, welds)	A	A
h) Visually inspect structural supports and mounting bolts are in place	A	A
i) Visually inspect for excessive vibration or movement when liquid is being supplied	S	S
j) Visually inspect insulation protective jacketing for cracks and holes	A	NA
k) Visually inspect nameplate legibility and attachment	A	A
Testing		
a) Measure remaining pressure vessel wall thicknesses where pitting or surface damage was visually observed	NA	Inspection Dependent
b) Proceed with Nondestructive Testing (NDT) to determine the extent of identified deficiencies where measured	NA	Inspection Dependent
c) Remove insulation as necessary to perform evaluation at the testing points if visual inspection indicates degradation of the insulation	Inspection Dependent	NA
d) Test and calibrate liquid level indicator sensor and controls	WA-A	WA-A
e) Test liquid level device sensor and controls	A	A
Maintenance		
a) Drain oil	As Needed	As Needed
b) Verify base frame anchors are in place and secure	WA-A	WA-A
c) Calibrate level control functions that are integral to safety shutdowns	WA-A	WA-A

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

10.1.1

*Where pitting, surface damage, general corrosion, or a combination thereof, is visually observed on a metal surface of the pressure vessel, deficient areas shall be further evaluated per Section 10.1.1.1.

10.1.1.1

Where pitting, surface damage, general corrosion, or a combination thereof, is suspected to have materially reduced the vessel wall thickness, the remaining wall thickness shall be measured using appropriate techniques.

10.1.1.1.1

*Where pitting, surface damage, general corrosion, or a combination thereof, has not materially reduced the vessel wall thickness beyond its permitted corrosion allowance, the pressure vessel metal surface shall be cleaned and recoated to arrest further deterioration.

10.1.1.1.2

*Where pitting, surface damage, general corrosion, or a combination thereof, has materially reduced the vessel wall thickness beyond its permitted corrosion allowance, the owner shall proceed in a timely manner with an analysis or using the following criteria to determine suitability for continued operation:

1. For line or crevice corrosion, the depth of the corrosion shall not exceed 25% of the original wall thickness.

2. Isolated pits may be disregarded provided their depth is not more than 50% of the required wall thickness of the pressure vessel (exclusive of any corrosion allowance), provided the total area of the pits does not exceed 7 in.^{2} (4,500 mm^2) within any 8 in. (200 mm) diameter circle, and provided the sum of their dimensions along any straight line within that circle does not exceed 2 in. (50 mm).

3. For a corroded area of considerable size, the thickness along the most critical plane of such area may be averaged over a length not exceeding 10 in. (250 mm). The thickness at the thinnest point shall be not less than 75% of the required wall thickness.

10.1.1.1.2.1

Where the pressure vessel is determined to be suitable for continued operation, the pressure vessel metal surface shall be cleaned and recoated to arrest further deterioration.

10.1.1.1.2.2

Where the pressure vessel is determined not to be suitable for continued operation, the owner shall proceed in a timely manner with one of the following methods:

1. Re-rate the pressure vessel to a lower design pressure,
2. Repair the pressure vessel with an “R” stamp holder,
3. Retire the pressure vessel from service (for decommissioning, see ANSI/IIAR 8), or
4. Replace the pressure vessel.

10.1.2

For insulated pressure vessels, where insulation is removed, partly or completely, for visual inspection or remaining wall thickness measurement(s), a protective coating shall be applied to the exposed metal surface and the insulation shall be replaced in accordance with the manufacturer's installation instructions after arresting any identified exposed pressure vessel metal corrosion.

10.1.3
*Steel pressure vessels used in closed-circuit ammonia refrigeration systems are not susceptible to wall loss due to internal corrosion.

10.1.4
During inspection, where an ASME nameplate cannot be identified on a pressure vessel, the owner shall proceed to meet the design requirements of ANSI/IIAR 2-2021 Section 5.14.4 Nameplates.

10.1.4.1
During inspection, where the original nameplate may be obscured by insulation, the owner shall proceed with insulation removal to permit inspection to identify the original nameplate, or the owner may install a replacement or duplicate nameplate that meets the requirements of Section 10.1.4.

10.1.4.2
Where a replacement or duplicate nameplate can be developed and installed, the installer shall hold an R-stamp.

10.1.4.3
Where the original pressure vessel nameplate or design information is illegible or no longer available preventing the development and installation of a replacement or duplicate nameplate, the owner shall provide historical ITM data, maintenance reports, or a combination thereof, to verify the pressure vessel has been maintained and has continuously operated safely or the owner shall proceed with the replacement of the subject pressure vessel in a safe and timely manner. The owner shall replace the nameplate in accordance with Section 10.1.4.2 and proceed with the pressure vessel recertification process in accordance with NBIC, ASME B&PVC, or replace the pressure vessel.

Chapter 11. Piping

11.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on carbon steel and stainless steel piping at the indicated frequencies, set forth in Table 11.1.

TABLE 11.1
Piping Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency			
	Insulated		Non-Insulated	
Inspection	Carbon Steel	Stainless Steel	Carbon Steel	Stainless Steel
a) Visually inspect metal surfaces for pitting or surface damage	NA	NA	A	A
b) Visually inspect for damage or moisture incursion in insulation (i.e. dampness, condensation, frost, ice buildup)	A	A	NA	NA
c) Visually inspect for indications of degradation of the protective coating (i.e., paint)	NA	NA	A	WA-A
d) Visually inspect supports for cracks and degradation	A	A	A	A
e) Visually inspect mounting bolts are in place	A	A	A	A
f) Visually inspect piping for indications of movement	A	A	A	A
g) Visually inspect seismic joints and restraints	WA-A	WA-A	WA-A	WA-A
h) Visually inspect materials used under roof pipe stands for indications of degradation (e.g., bases or sleepers)	WA-A	WA-A	WA-A	WA-A
i) Visually inspect piping supports are in place and for indications of degradation that could impede their ability to provide continued support of the piping as designed	A	A	A	A
j) Visually inspect insulation protective jacketing	A	A	NA	NA
k) Visually inspect condition of connections for leakage (i.e., interchanging parts - valves, fittings, flanges, bolting, gaskets) and threaded joints	NA	NA	A	A
l) Visually inspect to verify all piping system openings, except relief discharge termination points, are plugged, capped, or locked closed with appropriate administrative controls	A	A	A	A
m) Visually inspect to verify self-closing/quick-closing valves are installed on oil pots	A	A	A	A
n) Visually inspect ammonia refrigeration pipe labeling for correct placement, accuracy, and degradation	A	A	A	A
Testing				
a) Measure remaining wall thickness where pitting or surface damage was visually observed	NA	NA	WA-A	WA-A
b) Proceed with additional Nondestructive Testing (NDT) to determine the extent of identified deficiencies where measured	NA	NA	WA-A	WA-A
c) Remove insulation as necessary to perform evaluation at the testing points if visual inspection indicates degradation of the insulation	WA-A	WA-A	NA	NA
Maintenance				

a) Replace missing or broken hangers, hanger rods, and support saddles	A	A	A	A

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR – Not Required, Others as noted.

11.1.1

*Where pitting, surface damage, general corrosion, or a combination thereof, is visually observed on a metal surface of the piping, deficient areas shall be further evaluated per Sections 11.1.1.1 – 11.1.1.3.

11.1.1.1

*Where pitting, surface damage, general corrosion, or a combination thereof, has not materially reduced the remaining pipe wall thickness, the piping metal surface shall be cleaned and recoated to arrest further deterioration.

11.1.1.2

*Where pitting, surface damage, general corrosion, or a combination thereof, is suspected to have materially reduced the remaining pipe wall thickness, the piping remaining wall thickness shall be measured using appropriate techniques.

11.1.1.3

Where pitting, surface damage,, general corrosion, or a combination thereof, has materially reduced the remaining pipe wall thickness beyond the owner's established acceptance criteria, the piping shall be evaluated to determine suitability for continued operation.

11.1.1.3.1

*Where the owner does not have established acceptance criteria for pipe wall thickness from the original design or subsequent calculations, the owner or owner's designated representative shall establish a replacement thickness that should not be less than the calculated thickness for pressure containment in accordance with the code or standard in which the component is designed at its design pressure.

11.1.1.3.2

Where a pipe is determined to be at or below the owner's established replacement thickness, the owner shall immediately isolate the pipe from service and proceed with a plan for its replacement or decommissioning (for decommissioning, see ANSI/IIAR 8).

11.1.2

For insulated piping, where insulation is removed, partly or completely, for visual inspection or remaining wall thickness measurement(s), a protective coating shall be applied to the exposed metal surface and insulation shall be replaced in accordance with the manufacturer's installation instructions after arresting any identified exposed piping metal surface corrosion.

11.1.3

*Piping used in closed-circuit ammonia refrigeration systems is not susceptible to wall loss due to internal corrosion.

11.1.4 *Ammonia Transfer Hoses.

11.1.4.1

ITM tasks shall be performed on hoses used for the transfer of ammonia refrigerant that are compatible with ammonia and the oil used in the closed-circuit refrigeration system at the indicated frequencies, set forth in Table 11.1.4 or per manufacturers' instructions, unless a different frequency is justified in accordance with Section 5.2.1.

11.1.4.1.1
Hoses used to transfer to or from Department of Transportation (DOT) regulated bulk transport vehicles are not covered in the scope of this standard.

11.1.4.1.2
*Ammonia transfer hoses shall be installed before and removed after maintenance services that require ammonia refrigerant transfer to, from, or within the closed-circuit ammonia refrigeration system.

11.1.4.1.3
Where hose manufacturers do not provide recommendations for the testing and/or maintenance of their hose, replacing the hose when it reaches its expiration date is required. The expired hose shall not be used.

TABLE 11.1.4
Ammonia Transfer Hose Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency	
Inspection - Prior to each use and as indicated:	**Stainless Steel Braided**	**Nylon Braided**
a) Visually inspect hose for damage - crushed, kinks, bulges, blisters or soft spots, cuts, gouges, punctures, worn spots, or any other condition that exposes the braided reinforcement	A	A
b) Visually inspect hose coupling connections for any evidence of leaking	A	A
c) Visually inspect hose connection couplings, fittings, clamps, shields or guards, and bands for damage - cracks, looseness, slippage, movement, or misalignment of the coupling connection with the hose	A	A
d) Verify the hose has a minimum working pressure of 350 psig	A	A
e) Verify the hose is compatible with ammonia and the refrigerant oil	NA	A
f) Verify the hose has not reached the manufacturer's expiration date	A	A
Testing		
a) Hydrostatically pressure test per manufacturer's recommendations	AR	AR
Maintenance		
a) Replace hoses according to the manufacturer's recommendations	AR	AR

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA – Not Applicable, AR - As Required, NR - Not required, - Others as noted.

11.1.5 Ammonia Refrigeration Valves.

11.1.5.1
ITM tasks shall be performed on ammonia refrigeration valves at the indicated frequencies, set forth in Table 11.1.5.

TABLE 11.1.5
Ammonia Refrigeration Valves Inspection, Testing, and Maintenance Tasks*

ITM Task Description	Frequency			
	Insulated		Non-Insulated	
Inspection	Carbon Steel	Stainless Steel	Carbon Steel	Stainless Steel
a) Visually inspect metal surfaces for pitting or surface damage	NA	NA	A	A
b) Visually inspect for moisture incursion in insulation (i.e., dampness, condensation), frost, ice buildup	A	A	NA	NA
c) Visually inspect for indications of degradation of the protective coating	NA	NA	A	WA-A
d) Visually inspect valve supports for cracks and degradation	WA-A	WA-A	WA-A	WA-A
e) Visually inspect valve mounting bolts are in place	WA-A	WA-A	WA-A	WA-A
f) Visually inspect insulation protective jacketing and sealed joints	A	A	NA	NA
g) Visually inspect condition of valve flanges, bolts, and gaskets for leakage	NA	NA	WA-A	WA-A
h) Visually inspect that emergency shut-off valves are clearly and uniquely identified at each valve (at field location) and in the system schematic drawings	A	A	A	A
Testing				
a) Proceed with additional Nondestructive Testing (NDT) to determine the extent of identified deficiencies where visually observed	NA	NA	WA-A	WA-A
b) Remove insulation if necessary to perform evaluation	WA-A	WA-A	NA	NA
c) Functionally test system emergency shut-off valves Expected Result: That the emergency shut-off valve closed.	5	5	5	5
Maintenance				
a) Replace missing or broken hangers, hanger rods, and support saddles	A	A	A	A
b) Exercise and lubricate stems on system emergency shut-off valves	A	A	A	A
c) Exercise and lubricate stems on non-emergency shut-off valves	5	5	5	5

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR – Not Required, Others as noted.

*For Pressure Relief Valves (PRV's), see Chapter 13 Overpressure Protection Devices.

*For specified performance criteria requirements of Ammonia Refrigeration Valves, see ANSI/IIAR 3.

Chapter 12. Safety Systems

12.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on Safety Systems for Ventilation, Emergency Shutdown Switches, Ammonia Detection and Alarms, Computer Controls, and Emergency Eyewash and Safety Showers at the indicated frequencies, set forth in Tables 12.1 - 12.5.

TABLE 12.1
Ventilation Systems Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency
Inspection	
a) Verify automatic function of Temperature Control Ventilation	WA-A
b) Visually inspect ventilation equipment for damage and degradation	M
c) Observe for indications of excessive vibration in powered supply and exhaust ventilators	M
d) Listen for abnormal sounds	M
e) Visually inspect fan belt tension and its condition	W-S
f) Visually inspect emergency ventilation override switch for damage or degradation	S
g) Visually inspect emergency ventilation control switch for proper installation of signage	S
h) Visually inspect emergency air intake(s) for any obstructions to air flow	S
Testing	
a) Functionally test manual override of Emergency Ventilation Expected Result: That the emergency ventilation system turns on when the manual Override switch is activated.	A
b) Test sail switches, air flow sensors, or other means to verify function of emergency exhaust equipment	A
c) Functionally test intake louvers Expected Result: That the intake louvers open when the emergency ventilation System is activated.	A
d) Verify fan belt tension by measurement and its condition	WA-A
e) Functionally test emergency ventilation operation Expected Result: That the emergency ventilation system activates when the ammonia detector is exposed to a concentration that exceeds the setpoint.	M
Maintenance	
a) Lubricate exhaust fan components	WA-M
b) Replace fan belts	WA-5
c) Verify emergency ventilation override switch mounting is secure	S

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR – Not Required, Others as noted.

TABLE 12.2
Emergency Shutdown Switches Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency
Inspection	
a) Visually inspect for damage	S
b) Visually inspect for proper installation of signage	S
Testing	
a) Functionally test emergency shutdown switch Expected Result: That the compressors, pumps, and normally closed automatic valves inside the machinery room are de-energized when the switch is activated.	A
Maintenance	
a) Verify emergency shutdown switch mounting is secure	S

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

TABLE 12.3
***Ammonia Detection and Alarm Systems Inspection, Testing, and Maintenance Tasks**

ITM Task Description	Frequency
Inspection	
a) Visually inspect for proper identification signage adjacent to visible and audible alarm devices	S
b) Visually inspect electrical enclosures for covers to be in place or panel doors to be closed	S
c) Verify there is a portable (clipped or hand held) means to check for a concentration level of ammonia during a power outage	S
Testing	
a) Calibrate all ammonia detector sensors	S
b) Expose the ammonia detector to calibration test gas and verify refrigeration equipment shuts down at specified concentration levels	A
c) Expose the ammonia detector to calibration test gas to automatically activate the emergency ventilation system and verify it is operating	A
d) Functionally test alarms – audio and visual Expected Result: Be able to hear the audible alarm(s) and see the visual alarm(s) while activated as designed.	A
e) Functionally test the power failure trouble signal to a monitored location for a power loss to the ammonia detection system Expected Result: That an alarm signal is received at a monitored location if loss of power to the ammonia detection system occurs.	A
f) Measure audio alarm output level to have a minimum of 15 decibels (dBA) above average ambient sound level	Initially and whenever modifications to the area affect the sound level

g) Measure audio alarm output level of 5 decibels (dBA) above maximum sound level	Initially and whenever modifications to the area affect the sound level
Maintenance	
a) Verify sensor mounting is secure	A
b) Verify panel mounting is secure	A

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

TABLE 12.4
Computer Controlled Safety Systems Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency
Inspection	
a) Visually inspect for exposed control wiring or damage	WA-A
b) Inspect batteries for corrosion, leakage, or swelling	WA-A
Testing	
a) Calibrate all sensors involved in automatic shutdown	A
b) Functionally test safety alarm indicators Expected Result: Safety indicator(s) are activated on an HMI when a value exceeds the setpoint.	A
c) Test battery	WA-3
Maintenance	NA

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

TABLE 12.5
Emergency Eyewash and Shower Inspection, Testing, and Maintenance Tasks*

ITM Task Description	Frequency
Inspection	
a) Visually inspect piping connections for leaks	W
b) Visually inspect that each emergency shower and eyewash or eye/face wash area is well lit and identified with signage	W
c) Visually inspect protective covers or caps are installed on each eyewash or eye/face wash nozzle to prevent airborne contamination	W
d) Visually inspect each shower and eyewash or eye/face wash path of travel is free of obstructions	W
e) Visually inspect that valves supplying each shower and eyewash or eye/face wash are open and capable of providing full flow for 15 minutes	A
f) Visually inspect that each combination unit with a shower and eyewash or eye/face wash are arranged so they can be simultaneously used by the same user	A

g) Visually inspect that each shower and eyewash or eye/face wash can be traveled to and reached within 10 seconds from the hazard (approximately 55 feet)	A
h) Visually inspect that each shower and eyewash or eye/face wash is on the same level as the hazard or no more than one step up to access	A
Testing	
a) Ensure that each unit’s water supply valve turns from “Off” to “On” in one (1) second or less	W
b) Ensure that each unit’s water supply remains at full flow without the use of the user’s hands	A
c) Ensure the eyewash or eye/face wash is 33” to 53” (83.3 cm - 134.6 cm) from the surface the user is standing on (surface) and a minimum of 6” (15.3 cm) from a wall or other obstructions	A
d) Ensure showerhead is between 82” and 96” (208.3 cm to 243.8 cm) above the surface	A
e) Ensure eyewash or eye/face wash flushing fluid is a maximum 8” (20.3 cm) above the nozzles and is delivered to both eyes simultaneously	A
f) Ensure shower water column is 20” (50.8 cm) wide at 60” (152.4 cm) above the surface and the center line is 16” (40.6 cm) from obstructions	A
g) Ensure shower is capable of providing a minimum of 20 gallons (75.7 liters) per minute flow rate	A
h) Ensure eyewash is capable of delivering a minimum of 0.4 gallons (1.5 liters) per minute flow rate	WA-A
i) Ensure eye/face wash is capable of delivering 3.0 gallons (11.4 liters) per minute flow rate	WA-A
j) Ensure flushing fluid temperature is tepid [60 - 100°F (16 - 38°C)]	A
k) Ensure each combination unit provides full flow to both the shower and the eyewash or eye/face wash simultaneously	A
l) Ensure each drench hose meet the above eyewash or eye/face wash requirements	WA-A
Maintenance	
a) Activate both the shower and the eyewash or eye/face wash to flush all sediment and stagnant water from piping “dead leg” sections	W
b) Clean eyewash bowl and nozzles and reset protective covers or caps	W

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

** See ANSI/IIAR 2-2021, Section 6.7 and ANSI/ISEA Z358.1-2014 (R2020), W*orld Safety Standard for Emergency Eyewash and Shower Equipment*, Chapter 3, Reference Standard, Section 3.4.

Chapter 13. Overpressure Protection Devices

13.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on overpressure protection devices at the indicated frequencies, set forth in Table 13.1.

TABLE 13.1
Overpressure Protection Devices Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency	
	PRV	**Hydrostatic/Internal**
Inspection		
Pressure Relief Valve (PRV):		
a) Visually inspect for unbroken ASME seal	A	A
b) Verify legible nameplate/tag	A	A
c) Confirm "Installation Date" is less than 5 years' old	A	NA
d) Verify valve inlet piping does not include isolation valve	A	A
e) Verify discharge outlet piping valves are locked open	WA-A	WA-A
f) Verify discharge outlet piping supports are not missing or broken	A	A
g) Verify discharge outlet piping has no obstructions (nests, insects, debris)	A	NA
h) Verify atmosphere diffuser would not discharge within 20 feet of a building opening	A	NA
i) Verify inlet size, outlet size, set pressure, and capacity are compliant with PRV design records	5	5
j) Inspect rupture disc or discharge relief indicators	WA-W	NA
Testing	NA	NA
Maintenance		
a) Drain water from atmospheric relief discharge piping outlet	A	NA
b) Time-based frequency (PRV) testing and/or recertification or replacement	5 from Installation Date or When Lifted	When an operational indication occurs

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

13.1.1

Where pressure relief devices discharge to a water diffusion tank, the water level and condition of the water shall be maintained.

13.1.2

*Hydrostatic/Internal PRVs that relieve internal to another portion of the closed-circuit refrigeration system shall be tested, refurbished and/or recertified, or replaced when an operational indication occurs.

13.1.3

If trapping of liquid with subsequent thermal hydrostatic expansion is only possible during maintenance or service operations, engineering or administrative controls, or both, shall be permitted as the means of relieving or preventing overpressure.

Chapter 14. Purgers

14.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks shall be performed on purgers at the indicated frequencies, set forth in Table 15.1.

TABLE 14.1
Purgers Inspection, Testing, and Maintenance Tasks

ITM Task Description	**Frequency**
	Refrigerated or Non-Refrigerated
Inspection	
a) Visually inspect water level in water column is adequate	WA-D
b) Visually inspect unit is securely mounted	M
c) Visually inspect insulation for cracks and holes	A
d) Inspect piping for pitting or surface damage	A
Testing	
a) Manually cycle through active purge points	S
b) Confirm purger effectiveness with refrigeration system pressure/temperature relationship	WA-A
Maintenance	
a) Verify operation of all indicator lights	WA-A
b) Clean water bubbler	WA-A
c) Drain oil	A
d) Clean line strainers	A
e) Service solenoid valves with plunger kits	As Needed

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

Chapter 15. Ammonia Refrigerant and Secondary Coolants

15.1 *Inspection, Testing, and Maintenance Tasks. Inspection, testing, and maintenance tasks pertaining to the ammonia refrigerant and secondary coolants shall be performed at the indicated frequencies, set forth in Table 15.1.

TABLE 15.1
Ammonia Refrigerant and Secondary Coolants Inspection, Testing, and Maintenance Tasks

ITM Task Description	Frequency
Inspection	
a) Ammonia appearance in sight glasses	WA-M
b) Secondary Coolant color, clarity, and sediment	WA-M
Testing	
a) Ammonia contamination sample (systems operating in a vacuum)	WA-3
b) Secondary Coolant freeze point	WA-A
c) Secondary Coolant corrosion inhibitor	WA-A
d) Secondary Coolant pH	WA-A
Maintenance	
a) Water contamination removal, when identified	WA-A
b) Concentration correction to proper specific gravity (SG)	WA-A
c) Corrosion inhibitor correction	WA-A
d) pH balance correction	WA-A

Frequencies: D - Daily, W - Weekly, M - Monthly, Q - Quarterly, S - Semiannual, A - Annual, B - Biennial, 3 - Three Years, 5 - Five Years, 10 - Ten Years, WA - Where Applicable, NA - Not Applicable, NR - Not Required, Others as noted.

Part 3 Appendices

If options presented within the informative appendices are implemented, they must comply with the normative pertaining provisions of this standard.

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.1.1
This standard's implementation can be a benchmark/starting point for minimum safe requirements where individuals are responsible for developing and implementing inspection, testing, and maintenance programs for facilities with closed-circuit ammonia refrigeration systems using RAGAGEP.

A.1.2
A refrigeration system may need to be retrofitted if the current instrumentation, controls, safety systems, or a combination thereof are determined to be inadequate.

A.2.2
Frequency: The frequencies are intended to establish optimal time between tasks that are required by IIAR 6. Where a facility's onsite production is limited, not continuous, or both at a daily frequency, the planned inspection items can use a controlled monitoring and/or automatic record keeping on the off shifts (e.g., second, third shift, and/or night shift), weekends, during harvesting off seasons, and/or holidays when refrigeration personnel are not scheduled. If such business interruptions are expected at a facility that does not utilize controlled monitoring and/or automatic record keeping, the facility should have a procedure for monitoring the equipment and/or take determined log readings for record keeping, such as having trained personnel that would be onsite perform periodic rounds (e.g., security personnel, non-refrigeration maintenance personnel).

When other scheduling conflicts, interruptions, or other conditions do not allow the tasks to be performed as scheduled, it then becomes important that the required task frequencies be identified and complied with according to variances described in the frequency definitions. When the required task frequencies have not been followed, it should be noted on the inspection report, the task should be performed, and the task frequencies should be followed for all future tasks. The variance should not be used to "skip" tasks or perform fewer tasks than required in IIAR 6.

A.5.1
In the United States, all facilities are subject to OSHA's General Duty Clause requirements and EPA's General Duty Clause requirements. Additional items should be included in the maintenance and inspection program if the ammonia refrigeration system is covered by OSHA's Process Safety Management (PSM), the US EPA's Risk Management Program (RMP), or state regulations that exceed minimum requirements. Some of these additional items include:

1. Types of process equipment.
2. Written procedures.
3. Safe Work Practices (e.g., LOTO, Hot Work, Line Opening, and Confined Space).
4. Equipment deficiencies.
5. Quality assurance.

See IIAR's Process Safety Management & Risk Management Program Guidelines and IIAR's Ammonia Refrigeration Management Program (ARM) for specific guidance to comply with OSHA and EPA requirements.

The following IIAR Posters for safety practices are available: P1 - First Aid, P4 – PPE, & P5 – Oil Draining Guidelines.

A.5.1.1.1
See Section 2.2 "frequency" definition.

A.5.1.1.3
Expected results could be activation set points (+/-) or include a functional description of the control logic.

A.5.1.1.4
If a deficiency is found, the documentation for the resolution should include:

1. Identification of each designated responsible person assigned to remedy each deficiency identified;
2. Recommended corrective action(s) for each deficiency identified;
3. Description of corrective action(s) for each deficiency identified;
4. Expected completion date(s);
5. Actual completion date(s).

A.5.1.1.4.1
Deficiencies within the scope of the provision include minor deficiencies identified and corrected during routine inspections, such as rounds. For example, upon identifying a minor deficiency, such as a simple setting that requires an adjustment or the cleaning of an evaporative condenser water sump strainer, the operator notes such in the Log (Operator Transfer of Information). Deficiencies that require a return to address the situation, due to needing specific tools, more personnel, safe work procedures, etc., would also be documented in the log. The documented method's intent is to ensure the deficiency is addressed to completion. A Log (Operator Transfer of Information) would capture deficiencies addressed and communicated among operators between shifts.

A.5.1.3.2
See Section 2.2 "frequency" definition.

A.5.1.4
The facility may store additional maintenance materials, spare parts, and equipment that are suitable for the system application for which they will be used. This is typically done for materials, spare parts, and/or equipment that have long lead times.

A.5.1.5
A risk-based ITM strategy includes the study and risk ranking of equipment and system failures based on probability (likelihood) and consequence (severity). The risk-based assessment learnings are used as criteria to further enhance the development of ITM tasks for the equipment and systems for planning, implementing, and optimizing results. See Appendix E - Risk-Based Inspection, Testing, and Maintenance.

A.5.2
Occasional record keeping interruptions may occur from being reviewed once per day on weekends, during holidays, and/or during harvesting off seasons. This is when coverage by refrigeration personnel is not scheduled. During the next scheduled shift when a trained technician is back on duty, the assigned record

keeping activities should resume and be analyzed for comparison and current operating conditions. See Section 2.2 “Frequency” definition and Appendix A, Section A.2.2.

Maintenance requirements per manufacturer recommendations are often provided in run time hours.
For IIAR 6, the Calendar Basis allows flexibility as ranges for longer frequencies of Quarterly to Ten Year periods and takes precedence over Runtime Basis (hours).

A.5.2.1
A history of abnormalities exists where repeated abnormalities have occurred during five consecutive frequency ITM tasks as presently planned and scheduled that should be addressed in order to prevent a risk of operating outside of operating limits or risk an ammonia release. Due to risk on a case-by-case basis, an owner may choose to address consecutively identified abnormalities sooner.

Predictive maintenance technologies applied to equipment are permitted to cause justifying, analyzing, and decreasing or extending time between major maintenance activities. Examples of predictive maintenance technologies are oil analysis, vibration analysis, thermography, and shaft alignment.

Planned major maintenance activities may be referred to as “rebuilds” or “turnarounds”. Turnarounds are scheduled events where an entire process unit of an industrial plant is taken off-line for an extended period for revamp and/or renewal. Where seasonal harvesting exists, turnarounds, where applicable, are performed during the off season. It is the process from one major scheduled maintenance outage to the next. It generally starts before the plant is taken off-line and continues for a period of time after the scheduled maintenance has been completed. Turnaround is a blanket term that encompasses more specific terms such as Inspection & Testing (I&T), debottlenecking projects, revamps, and revitalization or regeneration projects.

A.5.2.2
The frequency period of a “WA - Where Applicable” designation for the task is used where the equipment does have that option or feature.

A.5.3
A Computer Maintenance Management System (CMMS) that is used by the facility that provides reliable record keeping for inspection, testing, maintenance, and logs and the documented information is readily accessible is permitted.

A.5.3.1
The owner or owner’s designated representative ensures the record keeping activities are performed. The owner or owner’s designated representative may perform the record keeping activities. The designated representative is the person responsible for performing the record keeping activities. This person should have a working knowledge of the system.

A.5.3.2
The original manufacturers’ design, operations, and maintenance documentation for each instrumentation device, including those ancillary devices used to fabricate an assembly or subassembly, should be obtained and filed. Where the original technical information and documentation cannot be found or no longer exists, such information can be developed in conjunction with a process hazard analysis in sufficient detail to support the analysis.

A.5.3.3
Refrigeration systems with an inventory of less than 10,000 pounds of ammonia used as the refrigerant requires filing and/or storing, at a minimum, the following refrigeration system documentation to comply with the U.S.

EPA's General Duty Clause requirements of Section 112(r)(1) of the Clean Air Act and with Section 5(a)(1) of the Occupational Safety and Health Act 29 U.S.C. § 654(a)(1). The IIAR's Ammonia Refrigeration Management Program (ARM) was developed specifically for smaller ammonia refrigeration systems:

1. Safety Data Sheet (SDS).
2. Ammonia Inventory. Some refrigeration systems use the operating inventory (i.e., top off charge amount in the system) as their maximum intended inventory. This operating inventory or maximum intended inventory is the ammonia inventory. If the refrigeration system has a separate maximum intended inventory from an operating inventory, the maximum intended inventory, is the ammonia inventory.
3. Refrigeration flow drawings can be block flow diagram(s) or simplified process flow diagram(s), or a combination of both.
4. Safe upper and lower limits for such items as temperatures, pressures, flows, or compositions.
5. Safety Systems.
6. Relief System Design should include the design basis.
7. Ventilation System Capacity should clarify its design.
8. Installation, operation, and maintenance manuals. Where the installation, operation, or maintenance manuals are no longer available from the original manufacturer, such information can be developed in conjunction with a hazard review in sufficient detail to support the analysis.
9. Manufacturer data report forms for all pressure vessels. This should include applicable U1, U-1A, U-3, UM forms with pressure calculations to determine the available corrosion allowance.
10. Equipment List.

The following additional information may be filed or stored:

1. A facility plan view.
2. Piping and instrument diagrams (P&ID's)
3. Electrical classification.
4. Material and energy balances.
5. Materials of construction.

Refrigeration systems with an inventory of 10,000 pounds or more of ammonia used as the refrigerant requires filing and/or storing store, at a minimum, the following process safety information documentation that provide the information on the hazards of ammonia, on the technology of the process, and on the equipment in the process to comply with OSHA's Process Safety Management of Highly Hazardous Chemicals (PSM) 29 CFR 1910.119, Section (d) Process Safety Information and the U.S. EPA's Risk Management Plan (RMP) 40 CFR Part 68, Section 68.65 Process Safety Information:

Information pertaining to the hazards of ammonia (i.e., the chemical used) in the process:

1. Safety Data Sheet (SDS).

Information pertaining to the technology of the process:

1. A block flow diagram or simplified process flow diagram.
2. Process Chemistry – Ammonia used as a refrigerant is not Process Chemistry.

3. Maximum Intended Inventory (Ammonia Inventory). Some refrigeration systems use the operating inventory (i.e., top off charge amount in the system) as their maximum intended inventory.
4. Safe upper and lower limits for such items as temperatures, pressures, flows, or compositions.
5. An evaluation of the consequences of deviations, including those affecting the safety and health of employees.
6. Where the original technical information for Items 1, 3, 4, and 5 no longer exits, such information can be developed in conjunction with a process hazard analysis (PHA) in sufficient detail to support the analysis.

Information pertaining to the equipment in the process:

1. Materials of construction.
2. As-built, or at a minimum redlined, piping and instrument diagrams (P&IDs).
3. Electrical classification.
4. Relief system design and design basis.
5. Ventilation system design.
6. Design codes and standards employed. For existing equipment designed and constructed in accordance with codes, standards, or practices that are no longer in general use, the facility can determine and document that the equipment is designed, operated, inspected, tested, and maintained in a safe manner.
7. Material and energy balances (for processes built after May 26, 1992).
8. Safety Systems [e.g., interlocks, detection, emergency pressure control system (EPCS), or other suppression type systems].
9. The facility is required to document that equipment complies with RAGAGEP. In order to comply, the RAGAGEP adopted by the facility must be known. It is recommended to document the adoption date for each of the RAGAGEP. Since codes and standards are updated on occasion, the documented facility adopted RAGAGEP and their adoption dates that pertain specifically to each separate refrigeration system is important. Each refrigeration system should have its own RAGAGEP filed and stored.

The following additional information may be filed or stored:

1. Operation and Maintenance Manuals (IOM).
2. Process hazard analysis (PHA) - initial and revalidated, where applicable.
3. Pressure Test Results. The pressure test results for system components being replaced for maintenance requirements, such as compressors, refrigerant pumps, heat exchangers, valves, gauges, regulators, pipe, tube, and fittings.

Pertaining to the Safety Data Sheet (SDS) in both lists for smaller and larger refrigeration systems, the SDS was historically called Material Safety Data Sheet (MSDS). A SDS meeting the requirements of the Hazard Communication Standard (20 CFR 1910.1200) may be used to comply with this requirement to the extend the SDS contains the required information. The minimum information on the hazards of ammonia used as the refrigerant include the following:

Toxicity
Permissible exposure limits
Physical data
Reactivity data

Corrosivity data
Thermal and chemical stability data
Hazardous effects of inadvertent mixing of different materials that could foreseeably occur.

Ammonia inventory is also known as the threshold quantity (TQ) of ammonia volume in a closed-circuit ammonia refrigeration system.

The relief valve list with set pressure and minimum rated capacity should have readily accessible information of the calculations for common discharge headers to show that they have adequately sized piping to prevent excessive backpressure on relief valves, or if built prior to 2000, have adequate diameter based on the sum of the relief valve cross sectional areas.

The ventilation system functional description should have readily accessible information about the capacity calculations.

Where manufacturers are no longer available (i.e., have gone out of business) and are unable to be contacted to request and provide manufacturer's original information (MOI) for equipment, components or systems, such information can be developed in conjunction with a hazard review for smaller systems or process hazard analysis (PHA) for larger regulated systems in sufficient detail to support the analysis.

The "current" system is what is presently in operation as the refrigeration system of which the minimum documentation records listed in Section 5.3.3 should be readily accessible.

A.5.3.4
The monitoring location receiving the alarm message should maintain a continuously updated contact list with phone numbers of the on-call trained operators. An auto-dialer connected to the alarm system that sends notifications automatically to a person or persons [e.g., an on-call trained operator(s), technician(s), and/or related department staff member(s); a security officer(s); or other assigned receiving designee(s)] or to a monitored location when an alarm activation occurs to provide a timely response is acceptable.

A.5.3.6.1
The means of record keeping, such as a log, to document and transfer pertinent operational, maintenance, and ongoing duty information between operators could include shift change notes, explanatory for equipment ITM tasks at hand (inspection, testing, and/or maintenance logs), nuisance reports or details at hand (leaks, intermittent issues or circumstances), incidents and incident investigations, round reports and explanatory field information, forthcoming tasks, safe work practices (hot work, lockout/tagout, confined space, line breaking, working at heights, ground disturbance, etc.) occurring and requiring transfer, etc.

A.5.3.6.4
Oil Consumption should be verified and analyzed to determine if excessive amounts of oil are being consumed and carried over into the refrigeration system. Where excess oil is being added, an investigation can be put into place to determine which particular machine or equipment is causing the increased usage. Increased requirements in oil draining is another indicator that should be verified and analyzed.

A.5.3.6.5 The lubrication should be checked periodically to determine if a particular machine or equipment is consuming excessive amounts of lubricant that needs to be analyzed by arranging an inspection and to anticipate a maintenance request for a repair (e.g., broken lube, clogged lubrication zerk) or for a bearing replacement.

Lubrication includes oils and lubricants for specific application requirements. Lubrication includes the use of compressor oil, the greasing of motor bearings, the lubrication of valve stems, and the lubrication of other ancillary parts as needed. Lubrication is intended to reduce friction and wear, provide anti-corrosion, cooling, sealing, and foreign substance displacement measures.

Some owners' lubrication records may use an Equipment Lubrication Log, an Equipment Oil Log, or an Equipment Grease Log. Also, some owners may combine their oiling and greasing under their Equipment Lubrication Log.

Lubrication, applied automatically or manually during maintenance tasks, should be in quantities in accordance with manufacturers' recommendations or based on historical experience.

A.5.3.6.6
The date of the planned future refurbishment and recertification or replacement of a pressure relief valve (PRV) for overpressure protection with the same manufacturer, model, number, and pressure setting is intended for the manufacturer or an approved service to refurbish and recertify the valves or the valves be replaced as a replacement-in-kind. A facility can choose to replace a pressure relief device with a different manufacturer so long as the replacement occurs no later than the planned replacement date. Since a different manufacturer's replacement would not be a replacement-in-kind, the facility should manage the change and update the log with the new valve's information, which includes a verification and an update to the new PRV's design basis, as required.

A.5.3.7
In Table 5.3.7, under "Type of Record," the record type: "Current System Records listed in Section 5.5.3" is intended to refer to records documenting the as-installed-and-operating system, for which such records should be readily accessible.

Maintaining the Daily Inspection Records and the Log (Operator Transfer of Information) for longer than twelve (12) months could provide historical operating conditions that can be useful for comparison and anticipation of future similar conditions that have occurred and will more than likely re-occur less frequently, such as during holidays, turnarounds, rebuilds, seasonal changes, production demand changes, etc.

A.5.4.1
The evaluation of an identified deficiency may include a ranking method to determine the severity and likelihood of what could result if the deficiency is not resolved and determine a time frame to assign a corrective action(s) to resolve the deficiency. The evaluation and corrective action determination may be simply addressed by the qualified assigned responsible person, require the arrangement and involvement of additional qualified individuals who are familiar with the specific refrigeration system or others who have expertise in engineering, operations, and/or maintenance of refrigeration systems.

A.5.4.2
Computers cannot detect many abnormal operating conditions where a qualified inspector can when they apply their senses of hearing, sight, smell, and touch.

A.5.4.2.1
Certain tasks, such as visually inspecting a compressor coupling for wear, require that the equipment be shut down. Operational constraints may prevent the equipment from being shut down during the scheduled fifth-year inspection by the qualified inspector that is not influenced by the facility. Additionally, some inspections

may require the use of special tools or personnel to remove guards or perform measurements, both of which may not be available during the scheduled fifth year inspection.

Trained operators and/or trained technicians that have been verified by the owner to perform the annual inspections are considered qualified inspectors.

The owner or owner's designated representative should confirm that the inspector is qualified to perform the inspection and certify the final inspection report.

To verify the qualified inspector will not be influenced by the facility's finances, record keeping, operations, maintenance, or management and will not present a conflict of interest when inspecting the facility's refrigeration system(s), the owner or owner's designated representative should consider the past work performed at that facility by any potential qualified inspector.

An independent or third-party inspection firm is not required to be used for the fifth (5^{th}) year annual inspections.

A facility may utilize a contractor service providing operators, technicians, or both for performing inspections while searching, hiring, and training replacement employees that are no longer employed at the facility, while employees are offsite for training, vacation, or leave of absence events, or both. Some locations may have identified that utilizing a contractor service for its coverage works better for the facility.

Each component or device installed on equipment, such as an oil pump on a compressor, should be inspected in accordance with the component or device manufacturers' recommendations. The manufacturers should provide the component or device manufacturers' recommendations used on equipment they manufacture. The owner or owner's designated purchaser should request and verify they obtained the component or device manufacturers' recommendations that are used on equipment from the manufacturer of such equipment.

A.5.5.1
Functional testing and calibration is intended to uncover failures before incidents occur.

A.5.5.2
Testing and calibration of protection devices that are integral to the function of shutting down equipment or a system include: compressor cutouts [e.g., low suction pressure cutout, high discharge pressure cutout, high discharge temperature cutout, low oil pressure cutout, and high liquid level cutout (typically used on a pressure vessel to prevent liquid from reaching a compressor through a suction line between a pressure vessel and a compressor)], ammonia detectors, and emergency shutdown switches.

A.5.5.3
Leak tests duration for proving closed-circuit system tightness after routine maintenance tasks need not be extensive but should be sufficient enough for individually inspecting all the mating surfaces (e.g., seals, joints, gaskets, etc.) using conventional methods (e.g., bubble test, leak detectors, sulfur sticks, electronic detectors).

A.5.5.4
After complete installations of a closed-circuit ammonia refrigeration system per ANSI/IIAR 4 or revisions

(modifications) to a closed-circuit ammonia refrigeration system per ANSI/IIAR 5, the ammonia refrigeration system is required to have been field tested for tightness (does not leak), evacuated, and if required, dehydrated in accordance with ANSI/IIAR 5. Pressure testing requirements for such, which are different than leak testing requirements, are in accordance with ASME B31.5 *Refrigeration Piping and Heat Transfer Components*, alternate methods with ASME B31.3, or both.

A.5.5.4.1.2
A positive pressure leak test for sub-atmospheric pressure portions of systems (i.e., that operate in or near a vacuum) is needed at a pressure that will not damage system components or result in relief valves to lift.

A.5.5.5
Examples of standby power sources are batteries and back-up fuel-driven generators.

A.5.6.1
Maintenance procedures include the appropriate determined and required personal protective equipment (PPE) that is worn when performing work on the ammonia refrigeration system, equipment, and devices. A maintenance procedure may indicate that a buddy system be practiced when performing specific maintenance tasks. The IIAR's *Introduction to Ammonia Refrigeration* contains a description of personal protection equipment (PPE) applicable to ammonia, as well as, the IIAR Poster P4. The IIAR Poster P5 provides Oil Draining Guidelines. Safe Work Practices are utilized during maintenance tasks, such as during hot work, a confined space entry, isolating (lockout/tagout) equipment or a system, line opening of a close-circuit, working at heights, and ground disturbances. These each require procedures where applicable and are utilized for maintenance routine and non-routine tasks.

A.5.6.2
A non-routine maintenance task is when different equipment or components are replacing existing equipment or components beyond a previously developed procedure, a typical replacement-in-kind, or both. A non-routine task may be part of a project that will change a portion of the refrigeration system and incorporates other safe work practices. A method to document the sequential closing and/or opening of multiple valves for isolation to provide service may need to be developed to ensure safe control. The documentation should capture the isolation sequence that provides accessibility prior to performing the maintenance service task on equipment or components and the reverse sequence to bring the equipment or components back on line once the service task is completed. A closed-circuit pipe line or multiple closed-circuit pipe lines may need to be open. Parts of a system, equipment, or piping, including secondary coolant circuits, may need to be removed that are being replaced. For example, a thermosyphon cooling pressure vessel may need to be replaced. The replacement vessel may be installed near the existing unit that is still in operation. Some of the piping may be installed on the replacement vessel in preparation for a system shutdown, equipment exchange, and tie-in. Once the replacement equipment is operating, the non-routine task may include the removal of any area equipment, components, or piping that could not be removed until the exchange and tie-in were completed. See Section A.5.6.1 in regard to additional maintenance procedures information.

A.5.6.3
Open flame devices, including but not limited to gas-fuel or oxy-fuel torches, are sometimes used for maintenance service that require heating, cutting, or welding. This section requires that a work plan be prepared to prevent an unwanted fire and to prevent an overpressure rupture due to increasing vapor pressure in a blocked section of piping or other equipment. The work plan must also address preventing equipment damage due to overheating of metallic or non-metallic materials. For example, cast iron components (e .g., valves or pump casings) and non-metallic components (e.g., gaskets, seals, o-rings, packing, and lubricants) can be damaged when subject to open flames.

The use of a lighter to light sulfur sticks would more than likely be addressed using a procedure.

A.5.6.3.1

External heat application options include the following:

1) Water - Where the water temperature is between 32°F and 180°F, provided the ammonia pressure is above 47.6 psig (i.e., above the freezing temperature of 32°F).
2) Forced Hot Air Devices - Where the air temperature is below 180°F.
3) Portable tools having an open flame - Where it cannot cut or reduce the mechanical integrity of the surfaces where the heat is applied.

Hot ammonia vapor passing over the surface of liquid ammonia is ineffective for vaporizing liquid ammonia. However, depending on the geometry of the equipment, components, or piping, ammonia vapor can effectively displace liquid ammonia.

During heat application, temperatures above 180°F should not be applied to valves or piping of the closed-circuit refrigeration system to avoid damaging materials (e.g., becoming brittle).

A.5.6.5
Control valves that modulate during normal operation are exercising during normal operation.

The refrigerant oil used in the ammonia refrigeration system can be used to lubricate the valves in the system (e.g., spindle stems).

Valves required for emergency shutdown of the system or equipment are required to be clearly and uniquely identified at the valve itself (i.e., in the field). Examples of unique identification include valve tags, signs, or both.

A.5.6.5.1
Valves should not be aggressively forced opened or closed by using oversized wrenches, lever arms, or other devices.

A.5.6.6
While performing controlled maintenance or service repairs on refrigeration systems, there are occasions where an alarm could activate causing a nuisance. Engineering or administrative controls, or both, can be developed and implement to avoid nuisance alarms during the maintenance or service repairs. For example, if an ammonia detection alarm could activate during coalescent filter changing on a screw compressor or during a liquid pump rebuild, a developed and implemented engineering or administrative control, or both, could prevent the nuisance alarm from causing an unnecessary alert or evacuation. During controlled maintenance or service repairs that require a portion of the closed-circuit refrigeration system be isolated, pumped down, and opened up to atmosphere, still may have a diminutive release of residual ammonia. The engineering or administrative control (e.g., an impairment procedure), or both, may have a controlled procedure for temporarily silencing an audio alarm, deactivating a visual alarm, or covering or sealing a detection inlet.

A.5.6.8
The owner is permitted to develop and incorporate defrost operational procedures, ice removal procedures using mechanical tools, or both, with determined frequencies to safely remove ice often enough to avoid excess accumulation.

A.5.6.11

Out-of-Service can pertain to refrigeration systems that are shutdown between seasonal harvesting of fruit, vegetables, catching of fish, or similar processing and/or for turnarounds for equipment rebuilds or modifications.

A.5.6.11.4

Deferred ITM Task are those tasks that were not performed during the shutdown period. For example, refrigerant equipment (e.g., compressor) that has been shut down for four (4) months will require one of each of the following applicable daily, weekly, monthly, and quarterly ITM Tasks and a Pre-Startup Safety Review (PSSR) to be completed before the equipment is placed back into service.

A.6.1

A high liquid level cutout is typically installed on a vessel where a compressor suction line is connected to a vessel. The purpose of a vessel's incorporated high-level control is to shut down associated compressors if a high ammonia liquid level is detected in the vessel. The intent is to protect compressors from liquid slugging. Designers sometimes choose to provide a high-level liquid alarm that activates prior to an automatic high-liquid level shutdown to allow operator intervention. See ANSI/IIAR 2-2021, Section 8.5.9.

Where jacket cooling of reciprocating compressors exists, the daily "Discharge Temperature" verifications will provide an indication to verify the coolant flow where it has increased.

The amperage of the oil heater circuit may be measured and compared to normal ranges as part of the evaluation of operation.

Shaft seal leak rates are typically based on an oil-drop-per-minute method that manufacturers of compressors usually provide. Shaft seal leak rate aids in determining when a compressor shaft seal requires replacement (as determined by the manufacturer). Methods vary, but typically involve oil flowing (through a tube or by other means) to a graduated container where collection volumes can be measured and a leak rate calculated.

"Indicator of Compressor Capacity" pertains to verifying the present operating load of an operating compressor.

Indications may be provided by one or more of the following:

1) A slide valve position dial indicator;
2) A panel display percentage reading [using a linear displacement sensor (4–20 mA value signal relayed to the panel, converted into a percentage of compressor capacity value)];
3) A variable frequency drive (VFD) indication;
4) An amperage reading; and
5) The number of cylinders loaded (energized coils by a panel readout or by a visual count), which correlates to the compressor capacity of an operating compressor.

A.6.1.1

A compressor's high discharge pressure cutout, otherwise known as the high-pressure cutout (HPCO), is a pressure limiting device. This pressure-limiting device is required to be tested during the initial startup and commissioning of the compressor (See ANSI/IIAR 5) and annually. The pressure limiting device is configured to shut down the compressor if the pressure-limiting device reaches its setpoint. It may be connected to an electromechanical or electronic controller.

Master gauges used for pressure calibration must be re-certified on a regularly scheduled frequency or immediately before each functional test, to a pressure standard or dead weight tester, traceable to the National Institute of Standards and Technology (NIST). The documentation for the results of the master gauge re-certification should be filed and readily accessible as required process safety information.

NIST is a measurement standards laboratory that is a non-regulatory agency of the United States Department of Commerce with a mission is to promote innovation and industrial competitiveness.

Where the calibration of the pressure sensor compared to the master gauge is verified at two pressures, the two pressures are 10% or more apart to meet the requirement. Examples for the calibration comparisons could occur between the pressure-sensor reading to the master gauge at 200 PSIG and 220 PSIG, or at 225 PSIG and 250 PSIG.

A.6.1.3
The low suction pressure cutout is used as an example because this cutout is permitted to have a valve installed between the compressor and the cutout.

A.6.1.4.1

Electromechanical Switch - Example procedures for permitted test methods:

1. Manipulation of discharge pressure to the shutdown set point:

Install a master gauge such that it reads substantially the same pressure as the pressure-limiting device. The compressor discharge pressure should be increased slowly either by raising the condensing pressure or throttling the compressor discharge stop valve (slowly closing and *NEVER* shutting the valve) until the trained technician can confirm that the cutout operates at the required setting on the master gauge. If the measured pressure exceeds the cutout set point without stopping the compressor, (the operator can immediately start opening the discharge valve and the compressor should be immediately shut down using e-stops) and repairs made. Caution is required when using this method as a failure of the pressure-limiting device to function at its set point will require immediate action on the part of the trained technician to avoid increased overpressure that might lead to opening of a safety pressure relief valve and a refrigerant release.

A method for raising the condensing pressure where multiple evaporative condensers exist involves sequencing the shut-off of an evaporative condenser water pump followed by shutting off the same unit's fans in sequence during the warmer season of the location. Slowly continue sequencing the shut-off of water pumps and fans of additional evaporative condensers as needed to raise the discharge pressure until the cutout pressure is reached and the cutout shuts the compressor down, verifying it passed the test. Although this method can take a significant amount of time (i.e., 4 - 8 hours or even longer), the slowly increasing discharge pressure can safely reach the cutout set pressure for the test. If the cutout does not shutdown the compressor at the cutout set point, only slightly raise the discharge pressure with continued sequencing of the evaporator pumps and fans (e.g., 1 - 2 psig). If the cutout still does not shutdown the compressor, stop and turn condenser fans and pumps back , on as needed to lower the discharge pressure. Isolate and lockout the compressor and replace the high-pressure cutout that failed the test. Test the new cutout on the compressor before putting it back into normal operation.

2. Using a check valve, bleed valve, and external pressure source:

A low-pressure drop check valve should be installed in the piping between the compressor and the pressure-limiting device. See Figures 1 & 2. A controlled pressure source and master gauge should be installed on a test connection at a test valve between the check valve and pressure-limiting device. The external pressure source can be a manually operated oil pump that uses an oil that is compatible with the refrigeration system or it can be a nitrogen bottle and a regulator to control the applied pressure. Pressure should be applied by the external source until the trained technician confirms that the pressure-limiting device is properly calibrated to the master gauge, and it is proven to shut down the compressor when the applied pressure reaches the cutout set-point. A bleed valve is required in parallel with the check valve that is closed during testing and opened during operation. The bleed valve is to ensure that high pressure is not trapped above the check valve giving the pressure-limiting device a false or inaccurate high reading during operation. Once calibration and proper function of the pressure- limiting device is proven, the pressure should be relieved properly and the calibration pump or nitrogen bottle and master gauge should be removed. It is permissible for the functions of the check valves, bleed valve, and access valve to be combined into a single block designed for this purpose.

Explanation of test methods that are not permitted:

1. Removal and bench testing of the pressure sensor:

This method is not permitted as it does not confirm the function of the pressure-limiting device to shut down the compressor. Additionally, it is prohibited to run the compressor with the pressure-limiting device not installed and able to sense an increase in discharge pressure.

2. Isolation of a shutdown compressor, followed by pressurization:

This method is not permitted as it does not confirm the function of the pressure-limiting device to shut down the compressor.

3. Reducing the cut-out set point:

This method is prohibited when using an electromechanical switch due to the inaccuracy of adjusting the set point down for test then back up to setpoint, without the ability to test at the actual cutout pressure.

A.6.1.4.2

Pressure Transducer or Transmitter Connected to an Electronic Controller - Example procedures for permitted test methods.

1. Manipulation of discharge pressure to increase it to the shutdown set point:

Install a master gauge such that it reads substantially the same pressure as the pressure-limiting device. The compressor discharge pressure should be increased slowly either by raising the condensing pressure or throttling the compressor discharge stop valve (slowly closing and *NEVER* shutting the valve) until the trained technician can confirm that the cutout operates at the required setting on the master gauge. If the measured pressure exceeds the cutout set point without stopping the compressor, the compressor should be immediately shut down and repairs made. Caution is required when using this method as a failure of the pressure-limiting device to function at its set point will require immediate action on the part of the trained technician to avoid increased overpressure that might lead to opening of a safety pressure relief valve and a refrigerant release.

A method for raising the condensing pressure where multiple evaporative condensers exist involves sequencing the shutoff of an evaporative condenser water pump followed by shutting off the same unit's fans in sequence during the warmer season of the location. Slowly continue sequencing the shut off of water pumps and fans of additional evaporative condensers as needed to raise the discharge pressure until the cutout pressure is reached and the cutout shuts the compressor, down verifying it passed the test. Although this method can take a significant amount of time (i.e., 4 - 8 hours or even longer), the slowly increasing discharge pressure can safely reach the cutout set pressure for the test. If the cutout does not shutdown the compressor at the cutout set point, only raise the discharge pressure with continued sequencing of the evaporator pumps and fans slightly (e.g., 1 - 2 psig). If the cutout still does not shutdown the compressor, stop and turn condenser fans and pumps back on as needed to lower the discharge pressure. Isolate and lockout the compressor and replace the high-pressure cutout that failed the test. Test the new cutout on the compressor before putting it back into normal operation.

2. Reduce the cut-out set point and raise the discharge pressure until shutdown occurs.

Install a master gauge such that it reads substantially the same pressure as the pressure limiting device. If a pressure transducer or transmitter is the pressure-sensing device used for the pressure limiting function, the high-pressure cutout set point can be reduced in the control panel to a level that can be easily achieved to verify shutdown for testing purposes. The compressor discharge pressure should be increased slowly either by raising the condensing pressure or throttling the compressor discharge stop valve until the trained technician can confirm that the cutout operates at the reduced pressure setting on the master gauge. If the measured pressure exceeds the cutout set point without stopping the compressor, the compressor should be immediately shut down and repairs made. Calibration of the pressure sensor against the master gauge should be verified at two pressures that are 10% or more apart to verify the accuracy of the calibration programmed into the controls and meet the requirement. Examples for the calibration comparisons between the pressure sensor reading to the master gauge could occur at 180 psig and 200 psig or at 225 psig and 250 psig.

3. Using a check valve, bleed valve, and external pressure source:

A low-pressure drop check valve should be installed in the pipe between the compressor and the pressure-limiting device. See Figures 1 & 2 below. A controlled pressure source and master gauge should be installed on a test connection at a test valve between the check valve and pressure-limiting device. The external pressure source can be a manually operated oil pump that uses an oil that is compatible with the refrigeration system or it can be a nitrogen bottle and regulator to control the applied pressure. Pressure should be applied by the external source until the trained technician confirms that the pressure-limiting device is properly calibrated to the master gauge and is proven to shut down the compressor when the applied pressure reaches the cutout set point. A bleed valve is required in parallel with the check valve that is closed during testing and opened during operation. The bleed valve is to ensure that high pressure is not trapped above the check valve giving the pressure-limiting device a false or inaccurate high reading during operation. Once calibration and proper function of the pressure limiting device is proven, the pressure should be relieved properly and the calibration pump or nitrogen bottle and master gauge should be removed. It is permissible for the functions of the check valves, bleed valve, and access valve to be combined into a single block designed for this purpose.

Explanation of test methods that are not permitted:

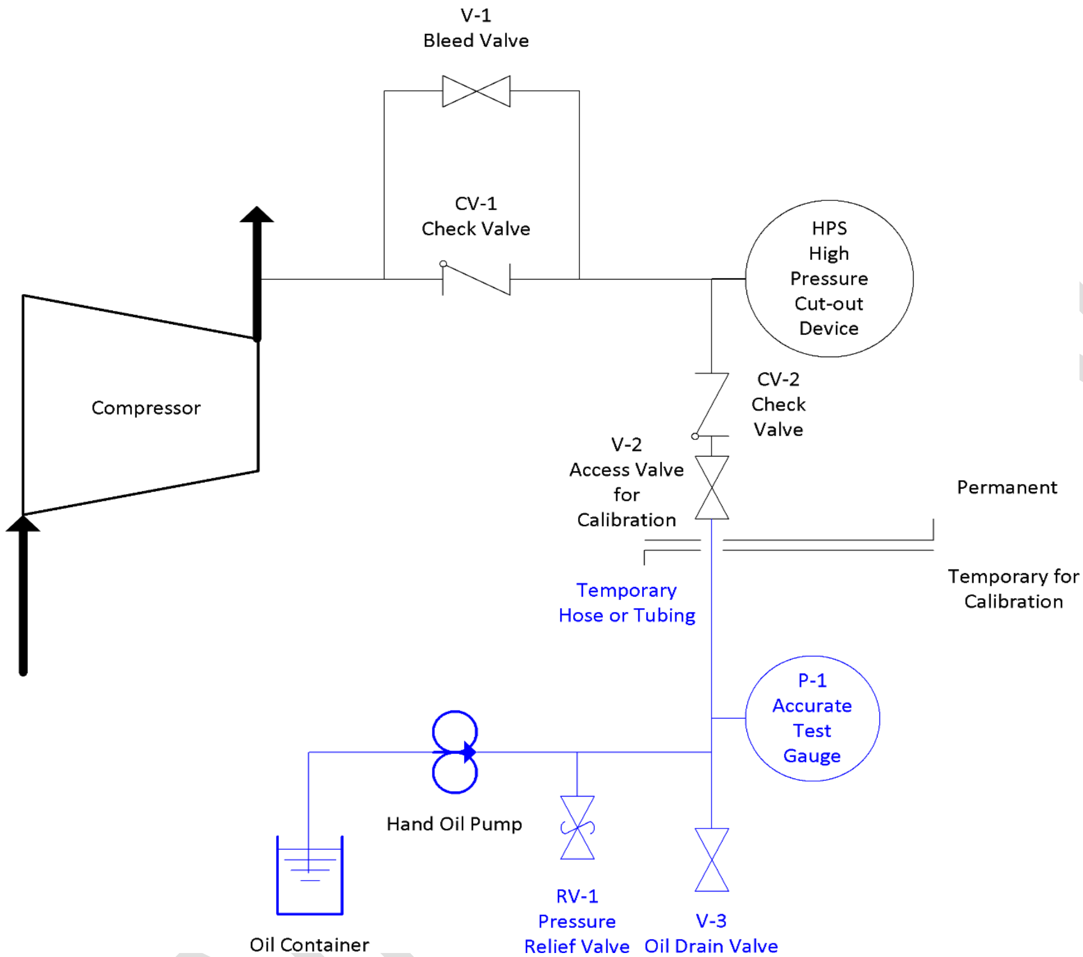
1. Removal and bench testing of the pressure transducer or transmitter.

This method is not permitted as it does not confirm the function of the pressure-limiting device to shut down the compressor. Additionally, it is prohibited to run the compressor with the pressure-limiting device not installed and able to sense an increase in discharge pressure.

2. Isolation of a shutdown compressor, followed by pressurization:

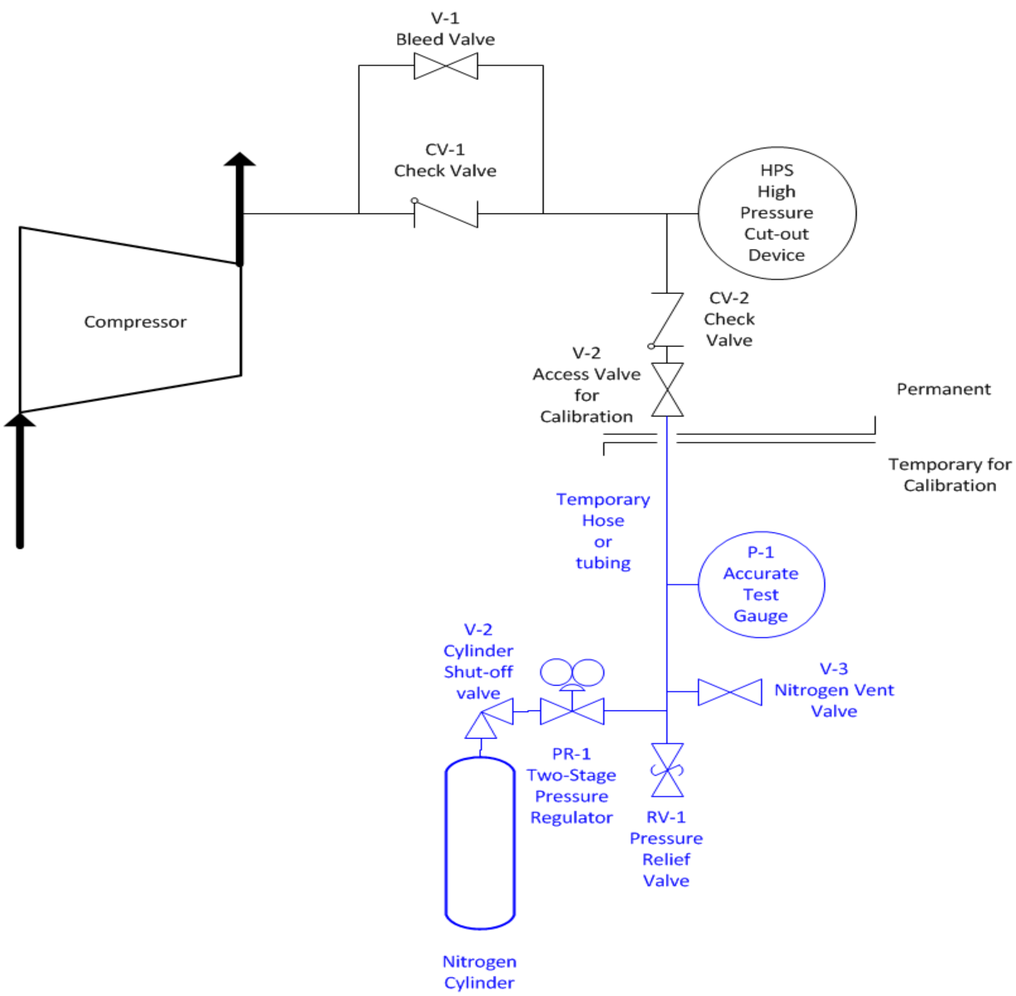
This method is not permitted as it does not confirm the function of the pressure-limiting device to shut down the compressor.

FIGURE 1
Test Method 3: Using Oil as the External Pressure Source



<u>Key Tasks for Figure 1:</u>
Open Bleed Valve V-1 and close Access Valve for Calibration V-2 when system is in normal operations.
Close Bleed Valve V-1 and open Access Valve for Calibration V-2 when testing the cutout.
Before removing the provided oil pressure source, drain the oil at the Oil Drain Valve V-3.
Cap, plug or use a test port at the outlet of Access Valve for Calibration V-2 when not testing.

FIGURE 2
Test Method 3: Using Dry Nitrogen as the External Pressure Source



<u>Key Tasks for Figure 2</u>:
Open Bleed Valve V-1 and close Access Valve for Calibration V-2 when system is in normal operations.
Close Bleed Valve V-1 and open Access Valve for Calibration V-2 when testing the cutout.
Before removing the provided dry nitrogen pressure source, use the Nitrogen Vent Valve V-3 to vent the induced dry nitrogen from the system.
Cap, plug, or use a test port at the outlet of Access Valve for Calibration V-2 when not testing.

A.7.1
An ammonia refrigerant pump used in an area other than a machinery room is required to be a Low-Probability Pump. A Low-Probability Pump is defined as follows:

Low-Probability Pump: 1. A pump that is permanently sealed to prevent atmospheric release of the pumped fluid, 2. A pump that incorporates a static seal to prevent atmospheric release of the pumped fluid, or 3. A pump that incorporates not less than two sequential dynamic shaft seals and automatically shuts down upon failure of any seal to prevent atmospheric release of the pumped fluid.

Option 1 includes hermetic and semi-hermetic liquid refrigerant pumps which are recommended as the best option for areas other than machinery rooms.

Refer to IIAR 2-2021 for the latest requirements concerning the location of open drive pumps. While some locations may not be suitable for open drive pumps, they may be allowed in others (e.g., outdoors, machinery rooms).

Regarding visual inspections of pump metal surface for pitting or surface damage, an iced-over pump will need to have the ice safety removed/melted or other obstructions moved to facilitate a complete inspection.

A.8.1
Highside heat exchangers on the refrigeration system can apply the ITM tasks included in Table 8.1. Heat exchangers on the highside of a refrigeration system may include water cooled shell-and tube, oil coolers, heat recovery units, and liquid subcoolers. The plate types may be gasketed plate-and-frame, welded plate-pair, or other. Liquid subcoolers may be a shell-and-tube type, shell-and-coil type, or a shell-and-plate type.

Plate (and Frame) Heat Exchangers are not typically pulled apart and internally inspected on a specific frequency for minimum safe requirements due to major unsafe releases do not result. Plate (and Frame) Heat Exchangers should be inspected every 10 years, as a suggested minimum. Shell-and-Tube Heat Exchangers typically have the tubes checked and tested on a 5-year minimum frequency or another justified frequency based on historical performance. Typical industry standard is to follow manufacturers' recommendations and run to failure. When failure occurs, external indications of leakage are identified by external staining, discoloration, or indications of a slight ammonia odor and internal indications are identified by cross contamination between the refrigerant and the medium or product being chilled, which is verified by periodic testing methods, discoloration of the refrigerant or chilled medium or product, or slight ammonia odor within the chilled medium or product. Frequencies of inspections are recommended to increase as the operating life of Plate (and Frame) Heat Exchangers and Shell-and-Tube Heat Exchangers advance in time.

During annual inspection, it is recommended to inspect for ammonia leaks using a handheld ammonia detector with the water shut off on evaporative condensers. Also, with shell-and-tube, as well as, plate-heat exchanger type condensers that use water as a medium, it may be beneficial to inspect for ammonia leaks with a handheld ammonia detector with the water shut off on these types of condensers as well. Air-cooled condenser types, which do not typically use water, can be inspected for ammonia leaks using a handheld ammonia detector. Some owners install a separate water spray mist on air-cooled condensers to give it the evaporative cooling effect. In this situation, the water spray mist on an air-cooled condenser is recommended to be shut off during inspections for ammonia leaks.

Condenser fan guarding may periodically become obstructed by foreign material such as plastic film, paper, cardboard, etc., causing the space behind the obstruction to experience a rapid pressure change. The pressure change can result in fan flex, which may lead to vibration, cracking, and catastrophic fan failure. Such failures may cause portions of the fan assembly to become airborne, which can cause property damage, refrigerant leaks, and injuries.

A.9.1
Other types of equipment used for cooling or chilling on the lowside of a refrigeration system can apply the ITM tasks as needed that are included in Table 9.1, where applicable. These other types of heat exchangers on the lowside of a refrigeration system may include liquid chillers, falling-film chillers, plate-or-tube ice makers, or orbital-rod evaporators. The plate types may be gasketed plate-and-frame, welded plate-pair, or shell-and-plate, or other.

Makeup hygienic units require air flow sensors be tested with a piezoelectric manometer for ensuring burner flames are within manufacturer specifications.

Frost accumulation on evaporator coils and surfaces is normal. Heavy ice accumulation is abnormal and should be addressed. The owner is permitted to develop and incorporate defrost operational procedures, ice removal procedures using mechanical tools, or both, with determined frequencies to safely remove ice often enough to avoid excess accumulation.

Plate-and-frame plates and gaskets should be inspected every 10 years. Typical industry practice is to follow manufacturers' recommendations or to run to failure (until a refrigerant odor becomes present).

Performing the visual inspection of a bunker coil with the coil defrosted and under adequate lighting conditions is recommended. This will allow the inspector to verify that the supporting hardware is performing according to its intended design.

Force-air evaporator fan guarding may periodically become obstructed by foreign material such as plastic film, paper, cardboard, etc., causing the space behind the obstruction to experience a rapid pressure change. The pressure change can result in fan flex, which may lead to vibration, cracking, and catastrophic fan failure. Such failures may cause portions of the fan assembly to become airborne, which can cause property damage, refrigerant leaks, and injuries.

Table 9.1, Test e): The manufacture recommended test might include exposure to artificial smoke or a simulated exposure, such as using a test button or method to activate a sequence. This could be shutting off fans, sending a signal, and/or closing valves and dampers.

Table 9.1, Test f): The manufacture recommended test might include exposure to artificial smoke or a simulated exposure, such as using a test button or method to activate a sequence. This could be shutting off fans, sending a signal, and/or closing valves and dampers.

A.10.1
Refrigeration system pressure vessels should be listened to for abnormal sounds. Abnormal sounds may be indications of hydraulic shock occurring, such as sudden liquid deceleration, vapor-propelled liquid, and/or condensate-induced shock and should be evaluated and addressed in a timely manner. See informative Appendix E*: Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock*.

Different types of visual liquid level indicators using glass as a "sight glass" are bull's eyes, tubular, or flat "armored" plate. The sight glass visual inspection should include the glass, retaining ring or other type fasteners, the gasket or gasket edges (if visible) and the housing for pitting, surface damage, and or misalignment. On the glass, look for nicks, cracks, chips, or other imperfections using illumination to provide black or oblique lighting. Verify adequacy and condition of guards, for example, visually inspect the entire length and 360-degree protection coverage for tubular sight glasses. See if tubular linear liquid level indicators have internal check shut-off valves that will stop flow in either direction if one side opens up.

Insulated pressure vessels [e.g. High Pressure Receivers (HPR's), Low Pressure Receivers (LPR's), Controlled Pressure Receivers (CPR's), Recirculators] with no external visual indications of moisture or corrosion under insulation (CUI) have been found with breachments of the insulation up or down stream of the pressure vessel that moisture had migrated between the insulation and the metal surfaces of the pressure vessel causing CUI, especially sections where thermal cycling occurs (precautions should be taken).

A.10.1.1
Pitting implies corrosion. Pitting corrosion is the formation of holes in an otherwise relatively un-attacked surface. Pitting is usually a slow process causing isolated, scattered pits over a small area that does not substantially weaken the vessel. It could, however, eventually cause a leak. Pitting can be measured with a pit gauge or other qualifying technique.

General corrosion implies surface rust and/or oxidation staining, which, by itself, has not materially reduced the remaining wall thickness.

A.10.1.1.1.1
Surface damage that has not materially reduced the remaining wall thickness may include scratches where the protective coating (i.e., paint) is removed and the vessel wall can be seen; oxidation of the surface (i.e., rusty color) without pitting, which can be wiped off by cleaning; or rub marks that can be felt by touch and are barely visible where an object may have bumped or pressed against the metal surfaces.

A.10.1.1.1.2
Where visual inspection cannot fully determine the condition of the pressure vessel, then additional nondestructive testing (NDT) is recommended. The additional NDT may require insulation removal. If insulation removal is necessary to conduct a test, the location or locations on the pressure vessel to be tested, should be selected based on experience with refrigeration pressure vessels with an increased probability of corrosion under insulation (CUI). A nozzle with pitting or surface damage in excess of the corrosion allowance should be evaluated for suitability for continued operation.

Pitting implies corrosion. Pitting corrosion is the formation of holes in an otherwise relatively unattacked surface. Pitting is usually a slow process causing isolated, scattered pits over a small area that does not substantially weaken the vessel. It could, however, eventually cause a leak. Pitting can be measured with a pit gauge or other qualifying technique.

Pressure vessel shells can be made of pipe and are very common up to 24 inches in diameter and, in some possible cases, may even be larger. A corrosion allowance on pipe provides additional wall thickness material which adds to the permissible wall loss.

Where the owner does not have record of the pressure vessel's required wall thickness, the owner should request this information from the pressure vessel manufacturer. Where the pressure vessel manufacturer or information is no longer available, an engineering assessment should be performed to establish required wall thickness values for the pressure vessel section(s) in question. See ASME Boiler and Pressure Vessel Code, Pressure Vessel, Section VIII, Division 1.

Appropriate Non-Destructive Testing (NDT) Methods:

Appropriate NDT methods include, but are not limited to, ultrasonic thickness testing, pit gage measurements, eddy current testing, ultrasonic testing for weld quality, ultrasonic testing for detection of cracks, liquid penetrant testing, magnetic particle testing, acoustic emission testing, radiographic testing, and radiometric testing.

Only technicians trained and qualified in the NDT methods that will be performed on a pressure vessel are permitted to do so in order to validate the inspection(s).

Method Categories:

1) Ultrasonic Testing - Uses ultrasound to detect indications in welds, plates, piping, components, and fittings associated with pressure vessels.

Ultrasonic Thickness Testing (UTT): Specifically designed to obtain the thickness of the heads, shell, nozzles, or other appurtenances of the pressure vessel.

Ultrasonic Shearwave Testing (UT): Designed to detect indications such as cracks, laminations, seams, laps, porosity, incomplete weld penetration, slag, and other anomalies associated with welds and plate manufacturing.

Ultrasonic Phased Array Testing (PAUT): More versatile ultrasonic system for performing both longitudinal and shearwave inspections.

Electro-Magnetic Acoustic Testing (EMAT): Allows for ultrasonic longitudinal and shearwave testing to be performed without the requirement a liquid or gel to couple the transducer to the test piece.

2) Radiography - Uses x-rays or gamma rays to produce images through the test piece.

Conventional Radiography Testing (RT): Uses film in conjunction with an x-ray tube or a gamma-ray source to produce x-ray images through the part being inspected.

Computed Radiography Testing (CR): Uses an imaging plate in lieu of film to obtain the x-ray image. The imaging plates are re-usable and the information is stored digitally.

Direct Radiography Testing (DR): Uses a digital imaging plate to deliver an x-ray image directly to a portable computer.

Computed Tomography Testing (CT): Combines multiple digital x-ray images to produce a 3-dimensional representation of the test piece.

3) Radiometry - Uses x-ray or gamma ray energy to penetrate a test piece and compare the attenuation received by the detector to make a measurement of some kind.

Radiometric Profiling (RP): A Gamma or X-ray beam is directed at a detector and attenuation of the beam is compared to a previously acquired calibration curve resulting in a material thickness measurement.

4) Magnetic Particle Testing - Uses iron particles interacting with a magnetic field to reveal surface and even subsurface indications present in ferrous materials.

Dry Magnetic Particle Testing (MT): Uses dry particles sprayed onto a magnetized surface to reveal indications like cracks or shallow voids in ferrous material.

Wet Fluorescent Magnetic Particle Testing (WFMT): Uses fluorescent magnetic particles suspended in a light oil solution sprayed on the test piece while a magnetic field is applied under a black light to reveal indications like cracks or shallow voids in ferrous material. This method is much more sensitive and will detect much smaller anomalies than dry methods.

5) Liquid Penetrant Testing - Uses a non-viscous liquid penetrant to seep into anomalies like cracks. Excess penetrant is removed and a dry developer is applied on the test piece which, through capillary action, draws penetrant out of any cracks thereby revealing their existence as a contrasting color upon the developer.

Visible Liquid Penetrant Testing (PT): Usually a red penetrant solution is used with a white developer agent. The amount of penetrant that the developer "wicks" out of a crack is directly related to the depth of the crack.

Wet Fluorescent Penetrant Testing (WFPT): Uses a fluorescent penetrant solution applied to the test piece. After the developer is applied, the test piece is viewed under a black light to reveal even minute indications open to the surface. This method is much more sensitive and will detect much smaller indications than non-fluorescent methods.

6) Acoustic Emission (AE) – Uses waveguides (metal bars) affixed to the vessel shell and heads. This method can be used on insulated vessels with minor insulation breaches at the locations where the waveguides are affixed to the vessel. This method can detect and locate areas of active cracking if present.

7) Pulsed Eddy Current (PEC) – Uses an electromagnetic inspection technology for detecting corrosion in ferrous materials typically hidden under layers of coating, fireproofing, insulation, or a combination thereof. Pulsed eddy current can also be used on insulated components that include aluminum, galvanized-steel, or stainless-steel weather jackets.

8) Visual Testing Examination (VT) – Uses observation by human vision in accordance with ASME for Pressure Vessels – ASME B&PV Code, Section V (Articles 1 and 9) and with ASME for Piping – ASME B31.5, Chapter VI.

Inspection Records - The following items should accompany any formal inspection report:

1) Facility Name
2) Vessel Name or number
3) National Board number (if available)
4) Name of inspection company and inspector
5) Date(s) inspection data was acquired
6) Condition of the vessel when inspected
7) Inspection results

Where pressure vessel insulation is removed, then the frequencies described for non-insulated pressure vessels should be used.

"Where Applicable – Annual" (WA-A) for testing to determine the remaining wall thickness of the pressure vessel is to be performed on the locations where pitting or surface damage were visually observed. Where no pitting or surface damage is visually observed, testing to determine the remaining wall thickness of the pressure vessel does not need to occur. The pressure vessel is considered at its original thickness or at its remaining wall thickness from the most recent test result.

Where pressure vessels are insulated and operate at temperatures below 25°F with ice accumulation around the full circumference of the pressure vessel and the ice accumulation is maintained below freezing (i.e., below 32°F) during temporary operational shutdowns, the pressure vessel is expected to be preserved and sustained to the similar conditions of previous inspection results. If damage were to occur to the pressure vessel insulation and/or vapor barrier, the owner should proceed with repairing and/or replacing the damaged pressure vessel insulation and/or vapor barrier in a timely manner. Due to the below freezing temperatures being maintained by the system operations and the timely replacement and/or repair of any damaged insulation and/or vapor barrier, the preserved pressure vessel should not have been subject to pitting or surface damage.

Pressure vessels of a refrigeration system that operate near 32°F (i.e., freezing temperature) and incur temperature/thermal cycling through defrosts or other temporary fluctuations in operating temperatures above and below freezing, are at an increased risk to the probability of CUI and are where NDT should be highly considered:

1. Pressure vessel nozzle connections.
2. Thermally cycled liquid level sections of the pressure vessel heads and wall.

If a sight glass in operation shows cloudiness, the internal surface should be cleaned, or it should be replaced.

ASME B&PV Code Section VIII, Division 1 permits a plate material under-tolerance of 0.010 inch or 6% of nominal thickness, whichever is less. In the case where the minimum allowable wall thickness (Tmin) is within the acceptable tolerance for plate, the actual thickness may be as low as the nominal thickness minus the acceptable tolerance. When Tmin is below the tolerance range for nominal plate, the measured thickness must equal or exceed Tmin to remain suitable for continued operation.

As an example, suppose a pressure vessel has a calculated Tmin of 0.370 inch. Plate material is ordered at nominal 0.375 inch. The allowable under-tolerance of the plate is up to 0.010, so the vessel is acceptable if the actual wall thickness is equal to or greater than 0.365 inch. As a second example if a pressure vessel has a calculated Tmin of 0.355 inch and nominal 0.375-inch-thick plate is ordered, the actual wall thickness must be greater than 0.355.

ASME B&PV Code Section VIII, Division 1 permits a 12.5% allowable tolerance on pipe wall thickness. As an example, a Schedule 40, 3-inch pipe nozzle has a nominal wall thickness of 0.216 inch, so the actual wall thickness on a nozzle or pipe shell would be acceptable down to 0.189 inch. Note: a corrosion allowance on pipe provides additional wall thickness material which adds to the permissible wall loss.

Line corrosion can occur in the area of intersection of the support skirt and the bottom of the vessel or liquid-vapor surface.

Pertaining to crevice corrosion, environmental conditions in a crevice can, with time, become different to the environmental conditions of a crevice on a nearby clean surface. A more aggressive environment may develop within the crevice and cause local corrosion. Crevices commonly exist at gasket surfaces, lap joints, bolts, etc. They are also created by dirt deposits, corrosive products, scratches in the protective paint and/or coating, etc. Crevice corrosion is usually attributed to one or more of the following:

a. Changes in acidity in the crevice,

b. Lack of oxygen in the crevice,
c. Buildup of detrimental ions in the crevice, and
d. Depletion of a corrosion inhibitor in the crevice.

A critical plane analysis, performed by a qualified engineer, refers to the analysis of stresses or strains as they are experienced by a particular plane in a material and the identification of which plane is likely to experience the most extreme damage.

A.10.1.3
Steel pressure vessels used in closed-circuit ammonia refrigeration systems are not susceptible to wall loss due to internal corrosion where excessive water contamination and noncondensables are managed.

A.11.1
Refrigeration system piping should be listened to for abnormal sounds. Abnormal sounds may be indications of hydraulic shock occurring, such as sudden liquid deceleration, vapor-propelled liquid, and/or condensate-induced shock and should be evaluated and addressed in a timely manner. If hydraulic shock has occurred, the pipe may have indications of movement. See informative Appendix E*: Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock*.

Indications of movement may include shifting, bending, broken, or missing pipe hangers, scratches and rub marks on the piping, saddles, or insulation jacketing surfaces from hangers that have moved, or cracked or failed welds at supports.

When inspecting pipe supports and hangers, they should be verified that they are not holding water, not corroded, clevis hangers are tight, and roof supports are adequate and have not been affected from expected dynamic loads and movement.

Insulated piping with no external visual indications of moisture or corrosion under insulation (CUI) have been found with breachments of the insulation up or down stream that moisture had migrated between the insulation and the metal surfaces causing CUI, especially where thermal cycling occurs (precautions should be taken).

A.11.1.1
Pitting implies corrosion. Pitting corrosion is the formation of holes in an otherwise relatively unattacked surface. Pitting is usually a slow process causing isolated, scattered pits over a small area that does not substantially weaken the piping. It could, however, eventually cause a leak. Pitting can be measured with a pit gauge or other qualifying technique.

General corrosion implies surface rust and/or oxidation staining, which, by itself, has not materially reduced the remaining wall thickness.

A.11.1.1.1
Surface damage to piping is considered to have materially reduced the wall thickness when the surface damage exceeds the owner's established acceptance criteria (See Section 11.1.1.3).

A.11.1.1.2
Where visual inspection cannot fully determine the condition of the piping, then additional nondestructive testing (NDT) is recommended. The additional NDT may require insulation removal. If insulation removal is necessary to conduct a test, the location or locations on the piping to be tested should be selected based on prior

experience with refrigeration piping and at locations with an increased probability of corrosion under insulation (CUI) to occur.

For appropriate Non-Destructive Testing (NDT) Methods, See Section A.10.1.1.2.

Where piping insulation is removed, then the frequencies described for non-insulated piping should be used.

"Where Applicable – Annual" (WA-A) for testing to determine the remaining wall thickness of the pipe is to be performed on the locations where pitting or surface damage were visually observed.
Where no pitting or surface damage is visually observed, testing to determine the remaining wall thickness of the pipe does not need to occur. The pipe is considered at its original thickness or at its remaining wall thickness from the most recent test result.

Where main headers are insulated and operate at temperatures below 25°F with ice accumulation around the full circumference of the piping and the ice accumulation is maintained below freezing (i.e., below 32°F) during temporary operational shutdowns, the piping is expected to be preserved and sustained to the similar conditions of previous inspection results. If damage were to occur to the pipe insulation, vapor barrier, or both, the owner should proceed with repairing and/or replacing the damaged pipe insulation and/or vapor barrier in a timely manner if the damage poses an immediate unsafe condition or could develop into an unsafe condition, such as excessive weight loading, to the piping. Due to the below freezing temperatures being maintained by the system operations, the preserved piping should not have been subject to pitting or surface damage.

Main headers and branch piping of a refrigeration system that operate near 32°F (i.e., freezing temperature) and incur temperature/thermal cycling through defrosts or other temporary fluctuations in operating temperatures above and below freezing, are at an increased risk to the probability of CUI and are where NDT should be highly considered:

1. Low temperature transfer piping.
2. Hot gas piping in cold ambient temperatures.
3. Liquid piping after control valves to vessels above 45 psig.
4. Defrost return piping.
5. Oil transfer and oil drain piping.
6. Hot gas pressurization piping for transfer.
7. Hot gas pressurization piping for heating.
8. Pump down/Pump out piping.
9. Equalization/Vent piping.

A.11.1.1.3.1
Table A.11.1.1.3.1 pertains to internal pipe-envelope pressure only. The table does not pertain to pressure vessel nozzles as described in Chapter 10 and Section A.10.1.1.2 above, nor does it account for seismic, thermal, or other dynamic loads. Structural loading conditions, including frost, ice, snow, wind, insulation, jacketing, and other external forces should have already been considered in the original design. Where structural loading conditions cannot be confirmed, an engineering assessment per ASME B31.5 should be performed.

Where the owner does not have established acceptance criteria for pipe wall thickness from the original design or subsequent calculations, the owner may consider using Table A.11.1.1.3.1 which provides minimum remaining pipe wall thickness values to determine repair or replacement conditions of carbon steel piping. Owners typically use or are encouraged to use more conservative "Alert Thickness" and "Replacement Thickness" values.

Where the owner does not have the piping minimum allowable wall thickness (tmin) from the original design or subsequent calculation per ASME B31.5 and a pipe wall “Alert Thickness” measurement from Table A.11.1.1.3.1 has been reached, the owner should develop a plan for its repair, replacement, or decommissioning.

Where the owner does not have the piping minimum allowable wall thickness (tmin) from the original design or subsequent calculation per ASME B31.5 and a pipe wall “Replacement Thickness” measurement from Table A.11.1.1.3.1 has been reached, the owner should immediately isolate the pipe (i.e., the pipe should be pumped out, isolated, locked and tagged out, and documented) and develop a plan for its replacement or decommissioning.

Table A.11.1.1.3.1
Piping Sizes, Schedules, and Thicknesses (Carbon Steel Only)

Pipe Size (in.) (OD)	Pipe Schedule	Nominal Thickness (in.)	*Mill Tolerance Thickness (in.)	Alert Thickness (in.)	Remaining Percentage from Nominal	Replacement Thickness (in.)	Remaining Percentage from Nominal	**Pressure Tmin (in.)
0.5 (0.840)	80	0.147	0.129	0.080	54%	0.044	30%	0.011
0.75 (1.050)	80	0.154	0.135	0.080	52%	0.046	30%	0.013
1 (1.315)	80	0.179	0.157	0.080	45%	0.054	30%	0.017
1.25 (1.660)	80	0.191	0.167	0.080	42%	0.057	30%	0.021
1.5 (1.900)	80	0.200	0.175	0.090	45%	0.060	30%	0.024
2 (2.375)	80	0.218	0.191	0.100	46%	0.065	30%	0.030
2 (2.375)	40	0.154	0.135	0.100	65%	0.046	30%	0.030
2.5 (2.875)	40	0.203	0.178	0.100	49%	0.061	30%	0.036
3 (3.500)	40	0.216	0.189	0.110	51%	0.065	30%	0.044
3.5 (4.000)	40	0.226	0.198	0.120	53%	0.068	30%	0.051
4 (4.500)	40	0.237	0.207	0.120	51%	0.071	30%	0.057
5 (5.563)	40	0.258	0.226	0.120	47%	0.081	31%	0.071
6 (6.625)	40	0.280	0.245	0.130	46%	0.094	34%	0.084
8 (8.625)	40	0.322	0.282	0.131	41%	0.119	37%	0.109
10 (10.750)	40	0.365	0.319	0.164	45%	0.146	40%	0.136
12 (12.750)	ST	0.375	0.328	0.194	52%	0.172	46%	0.162
14 (14.000)	ST	0.375	0.328	0.213	57%	0.188	50%	0.178
16 (16.000)	ST	0.375	0.328	0.244	65%	0.213	57%	0.203
18 (18.000)	ST	0.375	0.328	0.274	73%	0.238	64%	0.228
20 (20.000)	ST	0.375	0.328	0.305	81%	0.264	70%	0.254
24 (24.000)	ST	0.375	0.328	0.326	87%	0.315	84%	0.305

Adapted from *Principles and Practices of Mechanical Integrity Guidebook for Industrial Refrigeration Systems.*
*Mill Tolerance Thickness is 12.5% less than Nominal Thickness in accordance with ASME B31.5 and ASTM specifications.
**Pressure Tmin is in accordance with ASME B31.5 (300 psi, A53 Gr A ERW, Temperatures at or above -20 ºF).

Surface "fill and blend" is a technique that can repair small deficient sections of vessels and piping. This successfully applied technique can return vessels or piping to "like new" condition to again be suitable for service. This may not be the most cost-effective method, but the owner may adopt any proven method to return equipment to safe operating condition.

Pitting implies corrosion. Pitting corrosion is the formation of holes in an otherwise relatively unattached surface. Pitting is usually a slow process causing isolated, scattered pits over a small area that does not substantially weaken the piping. It could, however, eventually cause a leak. Pitting can be measured with a pit gauge or other qualifying technique.

General corrosion implies surface rust and/or oxidation staining, which, by itself, has not materially reduced the remaining wall thickness.

A corrosion allowance on pipe provides additional wall thickness material which adds to the permissible wall loss. Pressure vessel shells can be made of pipe and are very common up to 24 inches in diameter and, in some possible cases, may even be larger.

A.11.1.3
Steel piping used in closed-circuit ammonia refrigeration systems are not susceptible to wall loss due to internal corrosion where excessive water contamination and noncondensables are managed. Although rare, in a few instances, identified internal erosion has occurred where pressurized liquid flowed at a high velocity from a smaller pipe directly into the internal side of a larger pipe. A replacement should be considered using long bends or radiuses to prevent such internal erosion.

A.11.1.4
Ammonia Transfer Hoses:

Potential Hazards:

- Transfer hose failure, leading to a release of ammonia.

Possible Controls:

- Provide information pertaining to the hazards of ammonia to workers. For more information see Properties of Ammonia.
- Do not use old, damaged, or mistreated transfer hoses.

Ensure employees are trained in the proper care and maintenance of transfer hoses:

- Implement the following recommendations for the use of transfer hoses:
  - Inspect transfer hoses prior to each use.
  - Do not drag transfer hoses over sharp or abrasive surfaces, unless specifically designed for such.
  - Protect transfer hoses from severe end loads.
  - Ensure the pressure in the transfer hoses is at or below its rated working pressure.
  - Change internal transfer hose pressure gradually to prevent excessive surges.
  - Do not drive or run over transfer hoses with equipment.
  - Do not kink transfer hoses.
  - Use appropriate material handling equipment to move large transfer hoses.

- **Storage of transfer hoses:**
  - Protect transfer hoses from - Extreme temperatures, high or low humidity, ozone, excessive sunlight, oils, solvents, corrosive liquids and fumes, insects, rodents, radioactive materials.
  - Avoid stacking transfer hoses in such a way that the weight of the stack creates distortions to the hoses at the bottom.
  - Store transfer hoses in the original shipping container, if possible.

Perform a hydrostatic test per manufacturers recommended frequency:

- Test for five (5) minutes at 150-200% of the recommended working pressure.
- Test transfer hoses when they are straight, not coiled or kinked.
- Flush transfer hoses with alcohol to remove traces of moisture.
- Never use a compressible gas as test media due to the explosive action of the transfer hose if failure occurs.
- Bleed air through an outlet valve while filling it with the test medium.
- Place steel rods or other means of containment at transfer hose ends and at approximately every 10-foot intervals to prevent "whipping" movement.
- Bulwark or provide a means of containment structure at the outlet end of the transfer hose to contain hose component projectiles.
- Protect testing personnel from the forces of the testing media.
- Do not stand in front of or in back of the ends of the transfer hose being pressure tested.

Rubber transfer hoses that have an EPDM liner are not compatible with refrigerant oil.

A.11.1.4.1.2
Transfer of refrigerant from equipment, piping, and other system components may be required so that maintenance tasks may be performed safely.

Transfer of refrigerant occurs between a portion of the closed-circuit refrigeration system to another portion of the closed-circuit refrigeration system or to an approved container, cylinder, or tanker truck and then returned after the maintenance service is completed. Where ammonia refrigerant is delivered by a supplier, the tanker truck typically has its own certified ammonia transfer hose(s) for connecting from the delivery tanker truck to an owner's closed-circuit ammonia refrigeration system, which is handled by the trained delivery person. A copy of the ammonia transfer hose certification(s) and a copy of the delivery person's training verification can be requested (include requests on a purchase requisition) and provided by the tanker truck delivery person upon arrival.

Some anhydrous ammonia hose manufacturers refer to ARPM Publications IP-14 *Anhydrous Ammonia Hose, Specifications* and IP-11-2 *Anhydrous Ammonia Hose, Manual for Maintenance, Testing and Inspection.*

A.12.1
Where filters are installed on ventilation intakes of emergency ventilation systems, it should be verified that the intake filters do not reduce the emergency ventilation rate below 30 ACH and/or increase the negative room pressure inside the machinery room above 0.25 in. water column relative to the adjacent areas.

Obstructions to the emergency ventilation air intake could be dirty filters where filters are used, plastic, cardboard, etc.

Methods for activating the emergency ventilation equipment may include operating a manual override switch, pressing a hard (physical) or soft (control system) test button, or using test gas to expose the ammonia detector that triggers the emergency ventilation system. Upon activation of the emergency ventilation, ensure that all emergency ventilation fans (supply and exhaust) start and ramp up to the programmed motor frequencies for emergency ventilation, and that motorized air intake louvers, if present, open as required.

When presenting test gas to the ammonia detector for bump testing emergency ventilation systems, the test gas concentration should be limited to the full scale of the detector.

Functional testing can be done by manual activation or can be addressed and verified through automation (e.g., using instrumentation).

A.12.3 – Table 12.3

Testing of all ammonia detectors includes fixed and portable sensors (e.g., clipped and hand held).

A.12.5 - Table 12.5

Emergency Eyewash and Showers required by ANSI/IIAR 2 for safe design should be maintained, easily accessible (unobstructed), and operational for immediate emergency use. The primary regulation is contained in 29 CFR 1910.151(c), which requires that "…where the eyes and body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use."

The ANSI/ISEA Z358.1-2014 (R2020) standard provides requirements for the proper selection, installation, operation, and maintenance of emergency eyewash and shower equipment. Table 12.5 lists the recommended ITM tasks outlined in ANSI/ISEA Z358.1-2014 (R2020).

Where employees could be subject to exposure of hazardous material, such as anhydrous ammonia, they should be instructed in the location(s) and proper use of emergency eyewash and showers.

Flushing fluid flow rates can be visually verified by trained personnel or some other means. For inspection and testing, the shower flow rate could be verified by the following steps:

<u>Testing Steps</u>:
Step 1) Mark the 2.0-gallon water line on the 5.0-gallon bucket.
Step 2) Install a means of directing all the shower water into a 5.0-gallon bucket.
Step 3) Activate the shower for 6.0 seconds.
Step 4) Verify the water level reached the 2.0-gallon water line in a minimum of 6.0 seconds.
Step 5) Return the emergency shower to normal operation.

A means of directing all the shower water into a 5.0-gallon bucket can be with a shower sock as follows:
1) Connect the top of the sock around the showerhead.
2) Place the bottom of the sock into the 5.0-gallon bucket.

A.13.1

Pressure relief valves (PRV's) that relieve to the atmosphere are refurbished and recertified or replaced every five (5) years from the Installation Date unless an alternate interval of replacement has been established and justified by a pre-mortem testing method or a different recommended replacement interval is provided by the manufacturer.

When a pressure relief valve (PRV) is installed in the environment (harsh, high humid, thermal cycled through conditions of weather or sanitation conditions, risk of pitting or surface damage), condensation intrusion, pest intrusion (i.e. bugs, spiders), particulates (dirt), etc., it was determined and voted on, that the 5-Year interval cycle to refurbish and recertify or replace starts on the Installation Date since it is exposed to the above conditions in the environment whether under pressure for protection service or not.

Devices that are not U or UM stamped may be equipped with hydrostatic relief devices without an ASME stamp or seal.

When the cartridge is replaced for a cartridge-style PRV, the PRV is considered replaced.

Car seals are a simple device used to lock or “seal” a valve in the open or closed position to prevent unauthorized operation of the valve. Valve operation can only take place by cutting the seal, thereby giving evidence of either tampering or activity by an authorized person.

A.13.1.2
Hydrostatic/Internal PRVs are not subject to internal corrosion.

Internal/Hydrostatic pressure relief valves that discharge internally from a higher design pressure part of the system to a lower design pressure part of the system, are required to be tested, refurbished and/or recertified, or replaced when determined by indications identified by the required inspection tasks or replaced when an operational indication occurs.

Operational indications for when a hydrostatic/internal overpressure protection device is not operating correctly may include surging and fluctuating of pressures and temperatures, changes in equipment operating noise, or a combination of both. The operations could result in loss of equipment capacity and higher energy usage.

A.14.1
A refrigeration system operating at unusually high condensing pressure could have noncondensable gases causing the excess pressure if other system equipment is functioning properly.

Measuring for excess pressure due to noncondensable gases can be done by taking a temperature reading and a gauge pressure reading at the condenser outlet pipe. Using a Pressure/Temperature Chart, convert the temperature reading taken to pressure and subtract this from the actual gauge pressure reading taken.
If the gauge pressure reading is higher than the converted temperature-to-pressure reading, this is the excess pressure of the system, more than likely, due to noncondensable gases.

The effects of noncondensable gases can be unpredictable, due to the risk of combining with other contaminants (e.g., water, secondary coolant, oil) that may have entered the system causing organic acids and sludges. The noncondensable gases can lead to overpressure and possible rupture of equipment and piping, especially if exterior wall loss has occurred or the combined contamination can result in valves sticking closed or open and eventually damage internal equipment, component, and piping surfaces.

A.15.1
For water contamination measuring and removal, see informative Appendix C.

The effects of water contamination in an ammonia refrigeration system can be unpredictable. The pressure-temperature relationship is altered. The water itself can accumulate and freeze internally causing a system flow restriction leading to pressure buildup or risk of expansion and rupturing of components, devices, or piping. Chemical changes may occur to the compressor oil resulting in the formation of organic acids and sludges that can result in valves sticking closed or open and eventually damage internal surfaces of equipment, components, and piping.

Infiltration of other secondary coolants containing water to the refrigeration side of the system as cross-contamination can be identified by viewing the appearance of the ammonia, when testing for the water percentage determination, or both.

Immediate action should be taken to remediate the contamination before it creates collateral damage or activates latent mechanisms, such as Stress Corrosion Cracking (SCC).

If a sight glass in operation shows cloudiness, the internal surface should be cleaned, or it should be replaced.

The frequency for taking and testing an ammonia contamination sample was set at Three Years (3) due to some systems do not operate in a vacuum on the lowside. For systems that are not operating in a vacuum on the lowside, and no evidence of a secondary coolant leak exits in systems that are chilling a secondary coolant through a heat exchanger, the need for testing for contamination in the ammonia would be minimal. Systems that do operate in a vacuum on the lowside, have a questionable loss of secondary coolant, or both, may want to do a test "as needed" or do an annual (A) or biennial (B) test to determine the contamination rate of the system and provide a correctional plan to minimize the contamination. For stationary closed-circuit ammonia refrigeration systems, a Three Year (3) test for ammonia contamination was considered the minimum to ensure the owner knows the systems condition.

When topping-off a refrigeration system's refrigerant charge, due to loss of refrigerant from maintenance service, water contamination removal, purger losses, valve stem packing leaks, etc., the grade of the replacement refrigerant needs to be considered to ensure the closed-circuit refrigerant does not end up too dry and has some water. See Appendix C. (Informative) Water Contamination in Ammonia Refrigeration Systems, Section VIII Water Percentage Determination.

Appendix B. (Informative) Ammonia Refrigeration System Safety Checklists

The accompanying Ammonia Refrigeration System Safety Checklists can be used when performing safety inspections.

The checklists were originally in IIAR Bulletin No. 109 and constantly evolve with continuous improvement. Many owners adopted these checklists as a Recognized and Generally Accepted Good Engineering Practice (RAGAGEP) to meet the process safety requirements of their Process Safety Management (PSM) and Risk Management Plan (RMP) programs regulatory compliance requirements. Owners may continue to adopt and use these checklists as part of their RAGAGEP, which is documented in the Process Safety Information section of the programs.

In keeping with continuous improvement, the following safety checklists have been revised to more closely match the flow content of IIAR 6. For example, the original Ventilation checklist has been changed to "Safety Systems" and the IIAR 6 Chapter 12 Safety System items, that were also listed in the original IIAR Bulletin No. 109 General Safety checklist, have been moved to "Safety Systems". The remaining items in the original Bulletin No. 109 "General Safety" checklist are now included in a newly named "General System" checklist, which covers components and housekeeping not covered in the other checklist.

Other improvements included are as follows:

1) Added an Ammonia Absorption System checklist for non-listed systems that do not apply to other ANSI standards. If other system components are ASME certified, such as Heat Exchangers and Pressure Vessels, their specific checklists should be used.
2) Added secondary coolant pumps to the "Refrigerant Pumps" checklist. When inspecting coolant pumps, the ammonia specific checklist questions are generally not applicable (NA).
3) Revised all checklist questions so that a "Yes" answer generally should not need a Recommended Action and a "No" answer generally should have a Recommended Action.
4) Changed "Pressure Relief Valves" checklist name to "Pressure Relief System" and moved all relief valve and relief vent piping questions to this checklist. However, the relief valve data will still be recorded on each individual inspection checklist. Compressors should not have relief valve data, but the compressor oil separator reliefs or the thermosiphon oil cooler relief valve data would be captured on the respective pressure vessel form.
5) Revised all checklists to remove design data that only needs to be verified once, typically at startup. However, the design data required to inspect and verify safe operation and maintenance of an ammonia refrigeration system is included. For example, if a motor is identified operating above the FLA rating on the motor data tag, the Service Factor rating becomes necessary.
6) Revised all the equipment checklists so that the questions are specific to the individual equipment. The "General System", "Piping", "Pressure Relief System" and "Safety Systems" Checklists should cover the remaining portions of a refrigeration system.

The checklists include minimum items to consider and customization of these forms may be necessary and are permitted due to the specific equipment, specific components, configuration of your refrigeration system, and/or due to the implemented requirements of your facility's safety program (e.g., ARM/PSM/RMP).

Additional copies of these forms within Appendix B can be made and used where a system has multiple various equipment, such as more than one compressor, evaporator, pressure vessel, condenser, etc.

Ammonia Refrigeration Safety Inspection Checklist

AIR-COOLING EVAPORATOR

Location: ____________________ ID/Tag No.: ____________
Facility Owner: ____________________
Address: ____________________
Contact: ____________________ Phone: ____________
Inspector: Date:

Application:

- Blast Freezer ☐
- Storage Freezer ☐
- Storage Cooler ☐
- Dock ☐
- Process Room ☐
- Bunker (Bare) Coil Room ☐
- Other (Describe) ☐

____

Type of Refrigerant Feed:

- Liquid Recirculation (Top feed) ☐
- Liquid Recirculation (Bottom feed) ☐
- Flooded (Surge Drum) ☐
- Direct Expansion (DX) ☐
- Ammonia Absorption System ☐
- Other (Describe) ☐

____

Equipment Data and Limits:

Manufacturer: ____________ Model: ____________ Serial Number: ____________
Year Manufactured: ____________ Design Pressure (psig): ____________
Room Air Temp (°F): ____________ Suction (psig /°F): ______ / ______
Total Internal Vol: ________ Cu. Ft. Normal Ammonia Inventory (lbs.): ____________
Tube and Fin Material: ☐ Galv. Steel, ☐ All Stainless Steel, ☐ Aluminum, ☐ Stainless tube/Aluminum Fin
Defrost Type: ☐ Air, ☐ Water, ☐ Hot Gas, ☐ Other: ____________

Fan Motor Data:

Manufacturer: ____________ HP: ________ RPM: ________ FLA: ________
Frequency (Hz): ____________ Voltage: ________ Phase: ________ Service Factor: ________
Motor Type: ____________ Frame Size : ________ Enclosure: ________ Motor Qty: ________
Belt Type: ____________ Belt Size: ________ Belt Qty: ________

Ammonia Refrigeration Safety Inspection Checklist

AIR-COOLING EVAPORATOR

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Belts, sheaves, coupling, etc., in good working order and adequately guarded?	Yes ☐ No ☐ N/A ☐			
n) Free of pitting and surface damage and coils free of dirt? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
o) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

Ammonia Refrigeration Safety Inspection Checklist

AMMONIA ABSORPTION SYSTEM

Location: ______________________ ID/Tag No.: ______________
Facility Owner: ______________________
Address: ______________________
Contact: ______________________ Phone: ______________
Inspector: ______________________ Date: ______________

Equipment Data and Limits:

Manufacturer: ______________ Model: __________ Serial Number: __________
Year Mfg.: ______ Listed Certification: __________ Design Temp. (°F): __________
Voltage: ______ Phase: ________ FLA: ________ Design Press. (psig): __________

Absorber Data: (If ASME approved, use the Vessel Inspection Checklist)

Material of construction: ☐ Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ______________
Absorbent Medium: ☐ Liquid-Vapor, Type Liquid: __________ ☐ Solid-Vapor, Type Solid: ________
Design Temperature (°F): ____________ Operating Temperature (°F): ______________

Generator (Desorber) Data:

Material of construction: ☐ Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ______________
Generator Heat Source: ☐ Gas, Type: ________, ☐ Electric, ☐ Waste Heat, Fuel Used: ________
Design Temperature (°F): ____________ Operating Temperature (°F): ______________

Rectifier Data:

Material of construction: ☐ Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ______________

Design Temperature (°F): ____________ Operating Temperature (°F): ______________

For other Ammonia Absorption System equipment or devices, use all applicable Ammonia Refrigeration System Safety Inspection Checklists such as Condensers, Heat Exchangers, Air-Cooling Evaporators, Pressure Vessels (for absorption vessel), Refrigerant Pumps (ammonia or secondary coolant), Pressure Relief Valves, Ventilation, General Safety, etc.

Are other applicable Ammonia Refrigeration System Safety Inspection Checklists used and attached? Yes ☐ No ☐
If No, explain:
____
____
____
____
____

Ammonia Refrigeration Safety Inspection Checklist

AMMONIA ABSORPTION SYSTEM

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) Adequate protection against traffic hazards?	Yes ☐ No ☐ N/A ☐			
j) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
k) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
l) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
m) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
n) Belts, sheaves, coupling, etc., in good working order and adequately guarded?	Yes ☐ No ☐ N/A ☐			
o) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
p) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

Ammonia Refrigeration Safety Inspection Checklist

COMPRESSORS

Location: ______________________ ID/Tag No.: __________
Facility Owner: ______________________
Address: ______________________
Contact: ______________________ Phone: __________
Inspector: Date:

Application:		**Type:**		**Oil Cooling:**	
High Stage	☐	Rotary Screw	☐	Shell & Tube	☐
Booster	☐	Rotary Vane	☐	Shell & Plate	☐
Single Stage	☐	Reciprocating	☐	Plate & Frame	☐
Swing	☐	Vertical Recip	☐	Welded Plate	☐
				Liquid Injection	☐
				Other	☐

Cooling Medium: Ammonia ☐, Water ☐, Glycol ☐, Other ☐

Equipment Data and Limits:

Manufacturer: __________ Model: __________ Serial Number: __________
Year Mfg.: __________ Refrigerant: ☐ Ammonia, ☐ Other: __________
Max Speed (rpm): __________ Min Speed (rpm): __________
Max Discharge Temp (°F): __________ Max Working Pressure (psig): __________
Max Oil Temp (°F): __________ Design Discharge Temperature (°F): __________

Operating Data:

Type of Drive: ☐ Belt, ☐ Direct, ☐ VFD Operating Speed: (rpm) __________
Direction of Rotation: ☐ Clockwise, ☐ Counter Clockwise Direction Arrow Installed? ☐ Yes, ☐ No
Saturated Suction (psig[Hg] / °F): _____ / _____ Discharge (psig/°F): _____ / _____

Relief Valve Data:

Manufacturer: __________ Model: __________ Year Installed: __________
Assembly: Type of Relief Valve: ☐ Internal, ☐ External
Pressure Setting (psig): __________ Capacity (lbs. air per min/SCFM): _____ / _____

Motor Data:

Manufacturer: __________ hp: __________ rpm: __________ FLA: __________
Frequency (Hz): __________ Voltage: __________ Phase: __________ Service Factor: __________
Frame Size: __________ Belt Qty: __________ Belt Size: __________

Safety Cutouts: Type: Pressure Switch = PS, Transducer = TD *Typically Fixed Factory Setpoints

Type:				**Type:**			
______	Low Suction Pressure Alarm	______	psig/ Hg	______	Low Oil Temperature Alarm*	______	°F
______	Low Suction Pressure Cutout	______	psig/ Hg	______	Low Oil Temperature Cutout*	______	°F
______	Low Suction Temperature Alarm	______	°F	______	High Oil Temperature Alarm*	______	°F
______	Low Suction Temperature Cutout	______	°F	______	High Oil Temperature Cutout*	______	°F
______	High Discharge Pressure Alarm*	______	psig	______	Low Oil Pressure Alarm*	______	psig
______	High Discharge Pressure Cutout*	______	psig	______	Low Oil Pressure Cutout*	______	psig
______	High Discharge Temp Alarm*	______	°F	______	High Discharge Temp Cutout*	______	°F

Ammonia Refrigeration Safety Inspection Checklist

COMPRESSORS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Drive train (belts, sheaves, coupling, etc.) in good working order and adequately guarded?	Yes ☐ No ☐ N/A ☐			
n) Free of modifications, alterations, damage or repairs such that casing integrity is or has been affected?	Yes ☐ No ☐ N/A ☐			
o) If No, has it been pressure tested and documentation on file?	Yes ☐ No ☐ N/A ☐			
p) At minimum, compressor has suction and discharge stop valves, and a discharge check valve?	Yes ☐ No ☐ N/A ☐			
q) Safety Cutouts functioning adequately?	Yes ☐ No ☐ N/A ☐			
r) At minimum, high pressure, low pressure, and differential oil pressure control devices are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
s) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
t) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe: ____

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Ammonia Refrigeration Safety Inspection Checklist

EVAPORATIVE CONDENSER

Location: ______________________________ ID/Tag No.: ______________

Facility Owner: ______________________________

Address: ______________________________

Contact: ______________________________ Phone: ______________

Inspector: Date:

Type:

- Water Spray .... ☐
- Adiabatic................. ☐
- Other .... ☐

Equipment Data and Limits:

Manufacturer: ______________ Model: ______________ Serial Number: ______________

Year Manufactured: ______________ Design Condensing Pressure (psig): ______________

Water Treatment Type: ☐ Chemical, ☐ Ozone Design Wet/Dry Bulb Temp (°F): ______ / ______

Total Internal Vol: ________ Cu. Ft. Normal Ammonia Inventory (lbs.): ______________

Tube and Fin Material: ☐ Galv. Steel, ☐ All Stainless Steel, ☐ Aluminum, ☐ Stainless tube/Aluminum Fin

Desuperheater installed? ☐ Yes, ☐ No

Fan Motor Data:

Manufacturer: ______________ hp: ________ rpm: ________ FLA: ________

Frequency (Hz): ______________ Voltage: ________ Phase: ________ Service Factor: ________

Frame Size: ______________ Belt Qty: ________ Belt Size: ________ Motor Qty: ________

Pump Motor Data:

Manufacturer: ______________ hp: ________ rpm: ________ FLA: ________

Frequency (Hz): ______________ Voltage: ________ Phase: ________ Service Factor: ________

Frame Size: ______________ Belt Qty: ________ Belt Size: ________ Motor Qty: ________

Purge Point Data:

Purge Type: ☐ Automatic Refrigerated, ☐ Manual Refrigerated, ☐ Manual Non-Refrigerated

If Auto Purger is installed, use the Purger Checklist. If Manual Purging, list number of purge points: ______________

Ammonia Refrigeration Safety Inspection Checklist

EVAPORATIVE CONDENSER

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Belts, sheaves, coupling, etc., in good working order and adequately guarded?	Yes ☐ No ☐ N/A ☐			
n) Water distribution system operating adequately?	Yes ☐ No ☐ N/A ☐			
o) Coils, water sump, strainers, and mist eliminators clean?	Yes ☐ No ☐ N/A ☐			
p) Corrosion monitoring system in place?	Yes ☐ No ☐ N/A ☐			
q) Free of pitting and surface damage and coils free of dirt? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
r) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

____
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Ammonia Refrigeration Safety Inspection Checklist

GENERAL SYSTEM

Location: ______________________ ID/Tag No.: ____________

Facility Owner: ______________________

Address: ______________________

Contact: ______________________ Phone: ____________

Inspector: Date:

This checklist applies to the general system components.

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) All components suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) Adequate protection against traffic hazards?	Yes ☐ No ☐ N/A ☐			
j) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
k) Oil removal provisions installed at all locations where oil accumulation is expected?	Yes ☐ No ☐ N/A ☐			
l) Oil drain valves are self-closing?	Yes ☐ No ☐ N/A ☐			
m) Sign on the outside of the machinery room prominently displays: a. Name and telephone of emergency contact(s) b. Maximum intended ammonia inventory c. Lubricant type d. Low side and high side design pressure	Yes ☐ No ☐ N/A ☐			
n) Are pathways in the machinery room clear of obstructions?	Yes ☐ No ☐ N/A ☐			
o) If the machinery room is larger than 1,000 sq ft, is there more than one exit from the machinery room?	Yes ☐ No ☐ N/A ☐			
p) All ammonia machinery room entrance doors have required placarding per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
q) Are exits clear of piping and other obstructions?	Yes ☐ No ☐ N/A ☐			

r) Covers securely fastened on all electrical panels and junction boxes?	Yes ☐ No ☐ N/A ☐			
s) Is a maintenance and repair log, including oil management, maintained?	Yes ☐ No ☐ N/A ☐			
t) Are ammonia cylinders connected to the system?	Yes ☐ No ☐ N/A ☐			
u) Machinery room floor and system clean of oil, grease and water?	Yes ☐ No ☐ N/A ☐			
v) At least one door is designated as a principal machinery room door and has required adjacent emergency ventilation and emergency shut down switches per ANSI/IIAR 2?	Yes ☐ No ☐			
w) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			
If No, describe: ______________________________				

Ammonia Refrigeration Safety Inspection Checklist

HEAT EXCHANGERS

Location: ____________ ID/Tag No.: ____________
Facility Owner: ____________
Address: ____________
Contact: ____________ Phone: ____________
Inspector: Date:

Type:

- Shell & Tube ☐
- Shell & Coil ☐
- Shell & Plate ☐
- Plate & Frame ☐
- Pipe in a Pipe ☐
- Vessel w/bare pipe coil ☐
- Falling Film ☐
- Scraped Surface ☐
- Plate Freezer ☐
- Jacketed Tank ☐
- Other (Describe) ☐ ____________

Function:

- Cascade Condenser ☐
- Product Condenser ☐
- NH3 Condenser ☐
- Chiller ☐
- Oil Still ☐
- Oil Cooler ☐
- Dehumidifier ☐
- Product Freezer or Cooler ☐
- Air Dryer ☐
- Subcooler ☐
- Ice Builder ☐
- Anhydrator ☐
- Other (Describe) ☐ ____________

Equipment Data and Limits:

Manufacturer: ____________ Model #: ____________ Serial #: ____________
ASME Cert. Stamp? ☐ Yes, ☐ No Year Mfg.: ____________ National Board #: ____________
Refrigerant Side: ☐ Shell, ☐ Plates, ☐ Tubes, ☐ Jacket, ☐ Both Sides, ☐ Other: ____________
Refrigerant Side MAWP (psig): ____________ @ °F ____________ MDMT (°F): ____________ @ psig ____________
Operating (psig /°F): ______ / ______ Normal Liquid Level: ____________
Total Internal Vol: ____________ Cu. Ft. Normal Ammonia Inventory (lbs.): ____________
Material: ☐ Carbon Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ____________

Level Indicator Type: ☐ None, ☐ Armored Bullseye, ☐ Level Column w/Bullseye, ☐ Flat Armored,
☐ Level Column Only, ☐ Level Column w/ Veri/Techni Level, ☐ Other ____________,

Relief Valve Data:

Manufacturer: ____________ Model: ____________ Year Installed: ____________
Assembly: ☐ Dual w/change over valve, ☐ Single Type of Relief Valve: ☐ Internal, ☐ External
Pressure Setting (psig): ____________ Capacity (lbs. air per min/SCFM): ______ / ______

Ammonia Refrigeration Safety Inspection Checklist

HEAT EXCHANGERS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate & ASME# legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Are pressure/temperature gauges and/or transducers present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Certification drawings on file?	Yes ☐ No ☐ N/A ☐			
n) Manufacturer data report on file?	Yes ☐ No ☐ N/A ☐			
o) Free of modifications, alterations, damage or repairs such that casing integrity is or has been affected?	Yes ☐ No ☐ N/A ☐			
p) If No, has it been recertified and documentation on file?	Yes ☐ No ☐ N/A ☐			
q) Are liquid level indicators adequately protected from impact?	Yes ☐ No ☐ N/A ☐			
r) Insulation free of damage, moisture, frost, vapor retarder leaks, etc.? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐ ☐ Not insulated			
s) Is the secondary cooling media circuit protected against over pressurization?	Yes ☐ No ☐ N/A ☐			
t) Free of pitting and surface damage and coils free of dirt? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
u) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe: ____

____

Ammonia Refrigeration Safety Inspection Checklist

PIPING

Location: ______________________ ID/Tag No.: __________

Facility Owner: ______________________

Address: ______________________

Contact: ______________________ Phone: __________

Inspector: Date:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) All components suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
b) Fasteners tight and adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
c) Safe access for inspection, testing, and maintenance?	Yes ☐ No ☐ N/A ☐			
d) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
e) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
f) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
g) Adequate protection against traffic hazards?	Yes ☐ No ☐ N/A ☐			
h) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
i) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
j) Are emergency shut-off manual and control valves, tagged, and exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
k) Piping arranged so liquid ammonia cannot be trapped between the pump discharge check valve and shut-off valve? a. If No, is there a properly piped relief valve installed?	Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐			
l) All ammonia drain valves fitted with plugs?	Yes ☐ No ☐ N/A ☐			
m) Are provisions to pump out equipment, control valves, and instrumentation installed?	Yes ☐ No ☐ N/A ☐			
n) All pressure and temperature gauges in good working order?	Yes ☐ No ☐ N/A ☐			
o) Installation conforms to ANSI/IIAR 2 RAGAGEP for the year installed?	Yes ☐ No ☐ N/A ☐			
p) Insulation free of damage, moisture, frost, vapor retarder leaks, etc.? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐ ☐ Not insulated			
q) Are pipe insulation support saddles in place?	Yes ☐ No ☐ N/A ☐			
r) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
s) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

Ammonia Refrigeration Safety Inspection Checklist

PRESSURE RELIEF SYSTEM

Location: ____________________ ID/Tag No.: ____________

Facility Owner: ____________________

Address: ____________________

Contact: ____________________ Phone: ____________

Inspector: Date:

This checklist applies to all relief valves, relief vent systems, and ancillary components.

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) All pressure relief valves and rupture discs have a legible nameplate?	Yes ☐ No ☐ N/A ☐			
b) All components are suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
d) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
e) Adequate protection against traffic hazards?	Yes ☐ No ☐ N/A ☐			
f) All relief piping has markers per ANSI/IIAR 2 Recognized and Generally Accepted Good Engineering Practices (RAGAGEP)?	Yes ☐ No ☐ N/A ☐			
g) Are relief valves in good condition?	Yes ☐ No ☐ N/A ☐			
h) All pressure relief valve set pressures are equal to or less than the equipment name plate MAWP?	Yes ☐ No ☐ N/A ☐			
i) All pressure relief valves have required discharge capacity?	Yes ☐ No ☐ N/A ☐			
j) All pressure relief valves have ASME seal intact?	Yes ☐ No ☐ N/A ☐			
k) Single or dual pressure relief valves are installed on all ASME certified pressure vessels, heat exchangers, oil pots, compressors, etc., as required by ANSI/IIAR 2 the year installed (or latest edition)?	Yes ☐ No ☐ N/A ☐			
l) All atmospheric pressure relief valves are connected above the liquid level?	Yes ☐ No ☐ N/A ☐			
m) All inlet piping to pressure relief valves conforms to ANSI/IIAR 2 the year installed (or latest edition)?	Yes ☐ No ☐ N/A ☐			
n) All outlet discharge piping from pressure relief valves conforms to ANSI/IIAR 2 the year installed (or latest edition)?	Yes ☐ No ☐ N/A ☐			

o) The extremity of all discharge piping to atmosphere is fitted with an approved ammonia diffuser and/or rain cover?	Yes ☐ No ☐ N/A ☐			
p) All pressure relief valves are located out of refrigerated space? a. If no, list precautions taken to prevent moisture migration into relief valve?	Yes ☐ No ☐ N/A ☐ ________________ ________________			
q) All pressure relief valves have been replaced or tested, repaired and sealed by an ASME certified agent within the last 5 years of service?	Yes ☐ No ☐ N/A ☐			
r) Relief valves are free of stop valves installed in pressure-relief inlets?	Yes ☐ No ☐ N/A ☐			
s) The cross sectional area of the opening through pipe, fittings, and pressure relief devices, including three-way valves, between a pressure vessel connection and its pressure relief device is not less than the area of the pressure relief device inlet?	Yes ☐ No ☐ N/A ☐			
t) Stop valves in relief discharge piping are locked open or car-sealed open with appropriate administrative controls?	Yes ☐ No ☐ N/A ☐			
u) Diffuser discharging to atmosphere does not discharge within 20’ of building openings?	Yes ☐ No ☐ N/A ☐			
v) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
w) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:
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Ammonia Refrigeration Safety Inspection Checklist

PRESSURE VESSELS

Location: ____________________ ID/Tag No.: ____________

Facility Owner: ____________________

Address: ____________________

Contact: ____________________ Phone: ____________

Inspector: ____________________ Date: ____________

Application:

- High Pressure Receiver...... ☐
- Accumulator....................... ☐
- Recirculator........................ ☐
- Intercooler.......................... ☐
- Transfer Drum.................... ☐
- Oil Separator .... ☐
- Oil Pot .... ☐
- Other (Describe)........... ☐ ____________________

Orientation:

- Horizontal .... ☐
- Vertical .... ☐

Equipment Data and Limits:

Manufacturer: ____________ Model #: ____________ Serial #: ____________

ASME Cert. Stamp? ☐ Yes, ☐ No Year Mfg.: ____________ National Board #: ____________

MAWP (psig): ____________ @ °F ____________ MDMT (°F): ____________ @ psig ____________

Operating (psig /°F): ______ / ______ Normal Liquid Level: ____________

Total Internal Vol: ____________ Cu. Ft. Normal Ammonia Inventory (lbs.): ____________

Material: ☐ Carbon Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ____________

Level Indicator Type: ☐ None, ☐ Armored Bullseye, ☐ Level Column w/Bullseye, ☐ Flat Armored, ☐ Level Column Only, ☐ Level Column w/ Veri/Techni Level

Relief Valve Data:

Manufacturer: ____________ Model: ____________ Year Installed: ____________

Assembly: ☐ Dual w/change over valve, ☐ Single Type of Relief Valve: ☐ Internal, ☐ External

Pressure Setting (psig): ____________ Capacity (lbs. air per min/SCFM): ______ / ______

Ammonia Refrigeration Safety Inspection Checklist

PRESSURE VESSELS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate & ASME # legible and secure per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Certification drawings on file?	Yes ☐ No ☐ N/A ☐			
n) Manufacturer data report on file?	Yes ☐ No ☐ N/A ☐			
o) Free of modifications, alterations, damage or repairs such that the vessel integrity is or has been affected?	Yes ☐ No ☐ N/A ☐			
p) If No, has it been recertified and documentation on file?	Yes ☐ No ☐ N/A ☐			
q) Are liquid level indicators adequately protected from impact?	Yes ☐ No ☐ N/A ☐			
r) Insulation free of damage, moisture, frost, vapor retarder leaks, etc.? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐ ☐ Not insulated			
s) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
t) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

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Ammonia Refrigeration Safety Inspection Checklist

PURGERS

Location: ____________________ ID/Tag No.: ____________

Facility Owner: ____________________

Address: ____________________

Contact: ____________________ Phone: ____________

Inspector: ____________________ Date: ____________

Type of Purging:

Automatic Refrigerated.......................... ☐

Manual Refrigerated .... ☐

Manual, Non-Refrigerated .... ☐

Equipment Data and Limits:

Manufacturer: ____________ Model #: ____________ Serial #: ____________

Year Mfg.: ____________ Design Pressure (psig): ____________

Operating (psig /°F): ______ / ______ Normal Liquid Level: ____________

Total Internal Vol: ________ Cu. Ft. Normal Ammonia Inventory (lbs.): ____________

Material: ☐ Carbon Steel, ☐ Stainless Steel, ☐ Aluminum, ☐ Other: ____________

Level Indicator Type: ☐ None, ☐ Armored Bullseye, ☐ Level Column w/Bullseye, ☐ Flat Armored, ☐ Level Column Only, ☐ Level Column w/ Veri/Techni Level

Relief Valve Data: ☐ **N/A**

Manufacturer: ____________ Model: ____________ Year Installed: ____________

Assembly: ☐ Dual w/change over valve, ☐ Single Type of Relief Valve: ☐ Internal, ☐ External

Pressure Setting (psig): ____________ Capacity (lbs. air per min/SCFM): ______ / ______

Purge Points:

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Purge Point: ____________ Purge Point: ____________

Ammonia Refrigeration Safety Inspection Checklist

PURGERS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
j) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
k) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
l) Can the purger be stepped through each purge point?	Yes ☐ No ☐ N/A ☐			
m) Is there frost/ice on the oil drain/pumpout line on the bottom of the evaporator chamber? If No, then the chamber may have oil and water in it and it needs to be drained?	Yes ☐ No ☐ N/A ☐			
n) Do indicator lights and check valves function correctly?	Yes ☐ No ☐ N/A ☐			
o) Does bubbler function correctly?	Yes ☐ No ☐ N/A ☐			
p) Installation conforms to ANSI/IIAR 2 Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) the year installed?	Yes ☐ No ☐ N/A ☐			
q) Are purge counts and times logged?	Yes ☐ No ☐ N/A ☐			
r) Insulation free of damage, moisture, frost, vapor retarder leaks, etc.? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐ ☐ Not insulated			
s) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
t) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

Ammonia Refrigeration Safety Inspection Checklist

REFRIGERANT PUMPS

Location: ____________________ ID/Tag No.: ____________
Facility Owner: ____________________
Address: ____________________
Contact: ____________________ Phone: ____________
Inspector: Date:

Application:

- Low Temperature Liquid Recirculation ..... ☐
- High Temperature Liquid Recirculation .... ☐
- Low Pressure Transfer .... ☐
- High Pressure Transfer .... ☐
- Other (Describe) .... ☐

____

Type:

- Open Centrifugal .... ☐
- Hermetic Centrifugal .... ☐
- Rotary Gear .... ☐
- Rotary Vane....................................... ☐
- Other (Describe) .... ☐

____

Secondary Refrigerant Type: ☐ Ammonia, ☐ Glycol, ☐ Water, ☐ Calcium Chloride, ☐ Other: ____________

Equipment Data and Limits:

Manufacturer: ____________ Model: ____________ Serial Number: ____________
Year Manufactured: ________ Design Pressure (psig): ________
Minimum Ref. Temp (°F): ________ Max Ref. Temp (°F): ________ Operating (psig /°F): ____ / ____
Total Internal Vol: ________ Cu. Ft. Normal Ammonia Inventory (lbs.): ____________
Material: ☐ Carbon Steel, ☐ Stainless Steel, ☐ Other: ____________
Type of Min Flow Bypass: ☐ Manual Valve, ☐ Other: ________ Max Speed (rpm): ________

1) Direction of Pump Rotation (viewed from drive end): ☐ Clockwise, ☐ Counter Clockwise

Relief Valve Data:

Manufacturer: ____________ Model: ____________ Year Installed: ____________
Assembly: ☐ Dual w/change over valve, ☐ Single Type of Relief Valve: ☐ Internal, ☐ External
Pressure Setting (psig): ____________ Capacity (lbs. air per min/SCFM): ____ / ____

Motor Data:

Manufacturer: ____________ hp: ________ rpm: ________ FLA: ________
Frequency (Hz): ____________ Voltage: ________ Phase: ________ Service Factor: ________
Frame Size: ____________ Belt Qty: ________ Belt Size: ________

Ammonia Refrigeration Safety Inspection Checklist

REFRIGERANT PUMPS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of excessive ice buildup?	Yes ☐ No ☐ N/A ☐			
g) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
h) Free of ammonia leaks?	Yes ☐ No ☐ N/A ☐			
i) All piping has markers per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
j) Are valves in good condition?	Yes ☐ No ☐ N/A ☐			
k) Are emergency shut-off manual and control valves tagged, exercised, and stems lubricated?	Yes ☐ No ☐ N/A ☐			
l) Sufficient pressure/temperature gauges and/or transducers are present and functioning adequately?	Yes ☐ No ☐ N/A ☐			
m) Belts, sheaves, coupling, etc., in good working order and adequately guarded?	Yes ☐ No ☐ N/A ☐			
n) Is hydrostatic relief valve or vent pipe installed?	Yes ☐ No ☐ N/A ☐			
o) Is minimum flow bypass valve installed and adequate?	Yes ☐ No ☐ N/A ☐			
p) Are Safety Limit Switches installed and adequate?	Yes ☐ No ☐ N/A ☐			
q) Insulation free of damage, moisture, frost, vapor retarder leaks, etc.? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐ ☐ Not insulated			
r) Where a system is operating in a vacuum, a refrigerant sample has been taken within the past 3 years to verify the ammonia is free of contamination and excessive water content?	Yes ☐ No ☐ N/A ☐			
s) Secondary Coolant is free of ammonia contamination?	Yes ☐ No ☐ N/A ☐			
t) Secondary Coolant concentration and freeze point adequately protects all components and equipment in the refrigeration system from freezing?	Yes ☐ No ☐ N/A ☐			
u) Secondary Coolant corrosion inhibitor, specific gravity, and pH	Yes ☐ No ☐ N/A ☐			

are in normal range per manufacturers guidelines?				
v) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
w) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			
If No, describe:				

Ammonia Refrigeration Safety Inspection Checklist

SAFETY SYSTEMS

Location: ______________________ ID/Tag No.: ____________
Facility Owner: ______________________
Address: ______________________
Contact: ______________________ Phone: ____________
Inspector: Date:

Ammonia Detector Data: (Use as many copies of this sheet as necessary to document all detectors)

Detector Type: ☐ Catalytic Bead, ☐ Electro-chemical, ☐ Opto-acoustic, ☐ Semi-conductor, ☐ Infrared, ☐ Rupture Disc, ☐ Other: ____________
Manufacturer: ____________ Model: ________ Alarm Levels (ppm): ________ Quantity: ______
Location(s): ______________________

Detector Type: ☐ Catalytic Bead, ☐ Electro-chemical, ☐ Opto-acoustic, ☐ Semi-conductor, ☐ Infrared, ☐ Rupture Disc, ☐ Other: ____________
Manufacturer: ____________ Model: ________ Alarm Levels (ppm): ________ Quantity: ______
Location(s): ______________________

Detector Type: ☐ Catalytic Bead, ☐ Electro-chemical, ☐ Opto-acoustic, ☐ Semi-conductor, ☐ Infrared, ☐ Rupture Disc, ☐ Other: ____________
Manufacturer: ____________ Model: ________ Alarm Levels (ppm): ________ Quantity: ______
Location(s): ______________________

Machinery Room Ventilation System: (Use as many copies of this sheet as necessary to document all exhaust fans)

Continuous Ventilation Fan Data: Quantity: ________
Manufacturer: ____________ Model: ____________ Serial Number(s): ____________
ID/Tag Number(s): ____________ Air Flow (cfm): ____________ Year Mfg.: ____________
Material: ☐ Galv. Steel, ☐ Stainless Steel, ☐ Aluminum Belt Qty: ________ Belt Size: ________

Intermittent (Temperature Control) Ventilation Fan Data: Quantity: ________
Manufacturer: ____________ Model: ____________ Serial Number(s): ____________
ID/Tag Number(s): ____________ Air Flow (cfm): ____________ Year Mfg.: ____________
Material: ☐ Galv. Steel, ☐ Stainless Steel, ☐ Aluminum Belt Qty: ________ Belt Size: ________

Emergency Ventilation Fan Data: Quantity: ________
Manufacturer: ____________ Model: ____________ Serial Number(s): ____________
ID/Tag Number(s): ____________ Air Flow (cfm): ____________ Year Mfg.: ____________
Material: ☐ Galv. Steel, ☐ Stainless Steel, ☐ Aluminum Belt Qty: ________ Belt Size: ________

Ammonia Refrigeration Safety Inspection Checklist

SAFETY SYSTEMS

Location: ID/Tag No.:

Inspection Items	Conforms	Safety Status	Recommended Action, or Comments	Target Date
a) Equipment labeled and nameplate legible per ANSI/IIAR 2?	Yes ☐ No ☐ N/A ☐			
b) Suitable for ammonia?	Yes ☐ No ☐ N/A ☐			
c) Operating within Limits?	Yes ☐ No ☐ N/A ☐			
d) Fasteners tight, adequately anchored and supported?	Yes ☐ No ☐ N/A ☐			
e) Safe access for Inspection, Testing & Maintenance (ITM)?	Yes ☐ No ☐ N/A ☐			
f) Free of abnormal sounds/vibration?	Yes ☐ No ☐ N/A ☐			
g) Sail Switch or other positive means is installed to activate a supervised alarm when airflow through an Emergency Exhaust fan stops?	Yes ☐ No ☐ N/A ☐			
h) Alarm works properly when an Emergency Exhaust Fan fails to run?	Yes ☐ No ☐ N/A ☐			
i) Ammonia detector(s) are calibrated per manufacturer recommendation?	Yes ☐ No ☐ N/A ☐			
j) An Ammonia Detector(s) is installed in the Machinery Room to automatically start Emergency Exhaust Fan(s) and activate a supervised alarm when ammonia is detected?	Yes ☐ No ☐ N/A ☐			
k) All Ammonia Detector(s), Control Circuits, Emergency Exhaust Fans, Dampers, Alarms and audio-visual annunciators function properly when detectors are bump tested with ammonia sample? a. List concentration level(s)?	Yes ☐ No ☐ N/A ☐			
l) Audio annunciators produce alarm output level of 5 decibels (dBA) above maximum sound level	Yes ☐ No ☐ N/A ☐			
m) The refrigeration system shuts down automatically when a detector's upper detection limit or 40,000 ppm (25% LFL), whichever is lower, is reached?	Yes ☐ No ☐ N/A ☐			
n) Can refrigerant compressors, pumps, and normally closed automatic valves be manually shut down with an emergency stop switch from outside the machinery room?	Yes ☐ No ☐ N/A ☐			
o) All belts, sheaves, couplings, bearings, dampers and filters are in	Yes ☐ No ☐ N/A ☐			

good operating condition and adequately guarded?				
p) Heat is installed and operating in Machinery Room for heat loss and continuous ventilation load?	Yes ☐ No ☐ N/A ☐			
q) Exhaust Fan discharges are located away from doors, windows and air intakes?	Yes ☐ No ☐ N/A ☐			
r) Intake Dampers are Fail-Open type?	Yes ☐ No ☐ N/A ☐			
s) Intake Louvers and Exhaust Fans are located to promote mixing and avoid short circulating room air?	Yes ☐ No ☐ N/A ☐			
t) Emergency Exhaust Fans can be manually started from outside of Machinery room?	Yes ☐ No ☐ N/A ☐			
u) Emergency Safety System signage is in place per the ANSI/IIAR 2 edition at time of installation?	Yes ☐ No ☐ N/A ☐			
v) Computer Control System functions properly and free of excessive alarms?	Yes ☐ No ☐ N/A ☐			
w) Shower and eyewash basins are installed in machinery room and just outside principle machinery room door and are maintained and functioning?	Yes ☐ No ☐ N/A ☐			
x) Ammonia respirators, air packs, and other approved emergency equipment available in conspicuous easily accessible locations outside machinery room?	Yes ☐ No ☐ N/A ☐			
y) All vessels connected directly to compressor suction equipped with high-level devices which sound an alarm and cutout compressors at high liquid levels?	Yes ☐ No ☐ N/A ☐			
z) Safety Cutouts functioning adequately?	Yes ☐ No ☐ N/A ☐			
aa) Are main shut-off valves (King liquid, hot gas and pumped liquid) prominently identified with signs?	Yes ☐ No ☐ N/A ☐			
bb) Main shut-off valves can be closed or source of pressure stopped from outside the Machinery Room?	Yes ☐ No ☐ N/A ☐			
cc) A written evacuation plan prominently displayed in a conspicuous location?	Yes ☐ No ☐ N/A ☐			
dd) At least one sign posted in a conspicuous location provides emergency instructions and phone numbers of emergency safety and operating personnel?	Yes ☐ No ☐ N/A ☐			
ee) In the event of a leak, can personnel exit quickly and safely?	Yes ☐ No ☐ N/A ☐			

ff) Free of pitting and surface damage? a. If No, Note damage level:	Yes ☐ No ☐ N/A ☐ Slight ☐ Extensive ☐			
gg) Free of any other conditions that negatively affect safe operation?	Yes ☐ No ☐ N/A ☐			

If No, describe:

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Appendix C. (Informative) Water Contamination in Ammonia Refrigeration Systems

This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has 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.

The information contained in these guidelines has been obtained from sources believed to be reliable. However, it should not be assumed that all acceptable methods or procedures are contained in this appendix, or that additional measures may not be required under certain circumstances or conditions.

The IIAR makes no warranty or representation, and assumes no liability or responsibility, in connection with any information contained in this appendix.

While the IIAR recommends use of and reference to this appendix by private industry, government agencies, and others, this appendix is intended to be voluntary and not binding.

The IIAR does not “approve” or “endorse” any products, services or methods. This appendix should not be used or referenced in any way which would imply such approval or endorsement.

I. Preface

Water contamination of the ammonia refrigerant is common in many refrigerating systems. The solubility characteristics of ammonia in water allows an aqueous ammonia solution, known as ammonium hydroxide, to be formed which replaces the anhydrous ammonia refrigerant.

Ammonium Hydroxide

$$NH_3 + H_20 \rightarrow NH_4^+ + OH^-$$

In many systems, this change occurs over a long period of time and the effects go unnoticed. As a result, the penalties experienced in coping with the changing conditions becomes continuous and increasingly greater.

The effects of the water contamination of ammonia refrigerant are many. The pressure-temperature relationship is altered. Chemical changes occur to the compressor oil. Organic acids and sludges are formed. Pump operation, piping pressure drop, and evaporator performance are adversely affected. The purpose of these guidelines is two-fold. One deals with the changes that occur in the pressure-temperature relationship of the refrigerant. The other relates to means for determining the presence of water, its measurement, its removal, and sources of contamination.

II. Ammonia-Water Relationship

Refrigeration grade ammonia is charged into a system whenever refrigerant is needed. Such ammonia is called anhydrous - meaning free of water. As long as a water free environment continues to exist, the pressure-temperature relationship shown in the ammonia refrigerant tables will be valid. Ammonia and water have a great affinity for each other. For example, at atmospheric pressure and a temperature of 86° F., a saturated solution of ammonia and water will contain approximately 30 % ammonia by weight. As the temperature of the solution is lowered, the ability to absorb ammonia increases. At 32° F, the weight percentage increases to 46.5 %; at -28° F, the percentage increases to 100 % ammonia by weight. This absorption, if allowed to occur, will cause the ammonia to be diluted by water. As dilution is experienced a change occurs to the anhydrous ammonia - it starts to become an aqueous ammonia solution.

III. Effects of Water Dilution

The pressure-temperature relationship for aqueous ammonia solutions is different than that for anhydrous ammonia. At a given pressure, the saturated temperature for anhydrous ammonia will be lower than the saturated temperature for an aqueous solution. As the aqueous solution becomes more diluted (water content is increased), the saturated temperature becomes higher.

The following lists the saturated temperatures for suction pressures of 8.9” vacuum, 0 psig, and 29.4 psig with water dilution varying from 0 to 30 %:

Dilution Percent	**Saturated Suction Temperatures**		
	8.9” Vacuum	**0 psig**	**29.4 psig**
0 %	-40.4°F	-28°F	16°F
10 %	-37.5	-25	19.4
20 %	-33.5	-20	25.7
30 %	-26.0	-12	36.2

Note that as the water percentage increases, the incremental increase in saturated suction temperature becomes greater. From the above data, it is obvious why water contaminated refrigeration systems must operate at lower suction pressure in order to maintain desired room temperatures or to handle process type loads.

With such a change in operating conditions, a two-fold penalty results. For each 1°F the saturated suction temperature is lowered, compressor capacity is reduced approximately 2½ % for high stage and 3 % for low stage (boosters). Likewise, as suction pressure is lowered, there is an increase in BHP/ton. Simply stated, less compressor capacity as well as increased power consumption are experienced.

IV. Water Sources

Water may gain entrance into a system in several ways:

1. Water may be in new pressure vessels which are not properly drained or dried following completion of a hydrostatic test.
2. During construction, water may enter through open piping or weld joints which are only tacked in place when exposed to the elements.
3. Condensation may occur in the piping during construction.
4. Condensation may occur when air has been used as the medium for the final system pressure testing.
5. Water that remains in the system as a result of inadequate evacuation procedures on startup or follow the opening of the closed-circuit system for repair or maintenance service.
6. Water may form as a result of complex chemical reactions in the system between the ammonia, oxygen, oils, and sludges.
7. Lack of adequate or no purging or from the use of improper procedures when purging into a water-filled container.
8. From the use of improper procedures when draining oil into a water-filled container from vessels in which the pressure is in a vacuum range.
9. Occasionally, a major contamination may occur as the result of the rupture of a tube or tubes in a shell-and-tube heat exchanger, such as chillers or oil coolers.
10. The most common source is through leaks that occur in systems which operate at a suction pressure below atmospheric pressure (i.e., in a vacuum). Water can gain entrance through leaks in valve stem packings, screwed and flanged piping joints, threaded and welded pipe connections, leaking safety relief valves, pump and booster compressor seals, and leaks in the coils of evaporator units.

V. Areas of Highest Water Content

Unless steps are taken to control the amount of water infiltration, there will be a continuous increase in water content in the refrigeration system over time.

In recirculating systems that use a refrigerant pump to provide the refrigerant supply to the evaporators, the highest water content will be found in the vessel that provides the liquid refrigerant to the inlet of the refrigerant pump(s). This would be the pump receiver or pump recirculator vessel.

In a gas-pressure system, this would be the controlled pressure receiver.

In flooded systems, the highest water content will be found in the evaporator and surge drum.

In direct-expansion (DX) systems, the highest water content will be found in the suction accumulator.

In two-stage systems, a high-water concentration will be found in the lowside system.

The reason for the concentration in the lowside is due to the large difference in vapor pressure between water and ammonia when heat, as the driving force, is absorbed. For example, at 35° F., the vapor pressure of ammonia is 66.3 psia compared to 0.10 psia for water. Since the liquid with the higher vapor pressure will evaporate in greater proportion than the liquid with the lower vapor pressure when heat is absorbed, a residue is left containing more and more of the lower vapor pressure liquid.

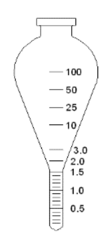
In all of the above instances, as the water content increases, the performance of all evaporators will progressively deteriorate.

VI. Detection of Water Contamination

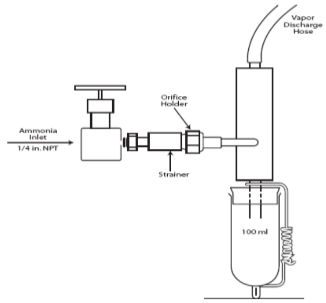
Detection of the effects of water contamination in a system may not be recognized. During this time, room temperatures may have been compromised, more compressors may have operated, suction pressures may have been lowered, and additional electrical energy may have been consumed and wasted.

The presence of water in the ammonia of a refrigeration system can be determined by a method similar to that used for testing samples of ammonia shipped by manufacturers or large distributors. A graduated sampling container kit can be obtained from a qualified manufacturer.

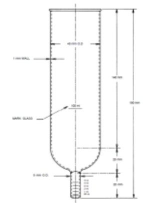
Graduated Sampling Container Kit – Two Examples



Sampler Kit (A) Graduated Container (enlarged)



Sampler Kit (B)



Graduated Container (enlarged)

Besides the sampler kit using a graduated container, the manufacturers' procedure will require a tool or method of handling and moving the graduated container (e.g., tongs), a water bath maintained at 80°F to 90ºF to help with the evaporation of the ammonia in the sample, assuring the area is well ventilated by using an existing ventilation system or staging the use of temporary exhaust fans, and the use of proper personal protective equipment (PPE). See Section IX for Safety Precautions.

Sampling Locations: Suggested locations from which to take samples are as follows:

Pump Systems: The pump discharge line.

Gas Pressure Systems: The transfer line between the transfer drum and the controlled pressure receiver.

Flooded Systems: The oil drain valve on the liquid leg of the surge drum.

Direct Expansion (DX) Systems: The liquid transfer line from the suction accumulator.

Sampling Procedures: The manufacturers' sampling procedure for using their graduated sampler container kit, which requires other recommended materials and arrangement for the area conditions, should be used as an appropriate step-by-step method of instruction for safely taking a test sample.

Charts can be used to estimate the amount of water contamination in the refrigeration system and to estimate the costs of the water contamination's presence. A 100-ml sample is taken for the test that correlates with how the charts for estimating are arranged. The graduated sample container has a 100-ml volume line, as well as other lower graduated content volume lines for also determining the residual amount of water after the ammonia evaporates. The graduated container can frost up during the evaporation of the ammonia from the sample. It is recommended to mechanically or physically mark the 100-ml line, so the frost cannot obscure the accurate reading and capturing of the 100-ml sample quantity.

VII. Water Percentage Determination

The residue remaining is a mixture of water, oil, non-volatile impurities and ammonia. If the temperature of the water bath was properly maintained, the water residue will contain approximately 30 % ammonia.

The procedures listed below have been modified from those used for more precise determinations of the presence of small quantities of water. The analysis is not concerned with small percentages in the range of 0.2 % (2000 ppm) or less, but with the determination of percentages ranging from higher percentage from 0.2 % (2000 ppm) to 30 % or more.

To determine percent by weight water contamination:

1. Record the operating pressure in the vessel from which the sample is taken. (Do not record the pressure in the line if the ammonia was pumped or transferred by gas pressure.)

2. From the following Evaporation Factor (EF) Table, use the pressure (PSIG) of the refrigeration system

that the sample was taken from to correlate and determine the Evaporation Factor (EF) to use in the below Section 5, Percent Water by Weight formula:

Evaporation Factor (EF) Table

PSIG	0	5	10	15	20	25	30	35	40	45	50
EF	0	.982	.966	.953	.940	.928	.918	.908	.901	.892	.886

The Evaporation Factor (EF) represents the percent of liquid ammonia remaining in the sample after a portion is lost due to flash as the sample is being taken.

3. Record the initial volume of sample in milliliters (ml).

4. Record the volume of residue in milliliters (ml).

5. Percent Water by Weight* =

$$\frac{\text{ml residue} \times 0.914 \times \text{EF}}{\text{ml sample}} \times 100$$

EXAMPLE:

1. Operating pressure in vessel is 29.4 psig.
2. Evaporation Factor (EF) is 0.919.
3. Volume of initial sample is 100 ml.
4. Volume of residue is 10 ml.
5. Percent water by weight =

$$\frac{10 \text{ ml} \times 0.914 \times 0.919}{100 \text{ ml}} \times 100$$

$$= 8.40\%$$

*See Section X for the derivation of the Percent Water by Weight formula.

Regarding the amount of moisture contamination, water content up to 0.2% (2,000 ppm) is acceptable.

Water content of 2% or more does not result in unsafe conditions and can cause measurable energy penalties.

The heads of pressure vessels should be hot formed or stress relieved after cold forming to inhibit *Stress Corrosion Cracking* (SCC). Water content in closed-circuit refrigeration systems may inhibit SCC in pressure vessels by scavenging the oxygen. For inhibiting SCC, especially where pressure vessels have not been hot formed or stress relieved after cold forming, a water content of 0.2% (2000 ppm) is considered optimal.

VIII. Removal of Water

The removal of water from a system is best accomplished by using a distilling process which is typically applied to operate as a batching system verses a continuous operation. A distilling unit may also be referred to as a regenerator or an anhydrator, depending on the manufacturer of the unit. Batch distilling units can be rented where the manufacturer can provide the design information and operating procedures. An owner may choose to design and construct their own portable unit, or an owner may even install a stationary batch distilling unit that is permanently attached to their refrigeration system or can be easily attached to portions of their refrigeration system, when and as needed. For minimum safe design requirements, see ANSI/IIAR 2. For minimum safe installation requirements, see ANSI/IIAR 4. For startup, see ANSI/IIAR 5. For developing an operating procedure, see ANSI/IIAR 7.

Where high water contamination is identified in a small ammonia refrigeration system that can be shut down, the full system's charge can be pumped out and recharged with new ammonia refrigerant.

Systems that have become contaminated should be investigated for the source of the water intrusion into the ammonia refrigeration system. If the source of the water intrusion cannot be readily identified and stopped, the facility should eventually plan a shutdown to pressurize and check the system for leaks and perform the necessary repairs before recharging and/or restarting the system.

IX. Safety Precautions

Safe working conditions and prudent concern for detail are absolutely necessary when performing sampling procedures. The review and full understanding of the manufacturers' procedure for instruction for all the necessary steps, as well as assembling all recommended equipment and materials needed, should occur prior to performing the sampling procedure. Taking a sample of refrigerant requires opening and closing the closed-circuit refrigeration system. It is crucial that a developed procedure includes the detail steps for opening and closing the sample point of the refrigeration system and safe work practices are applied, as necessary.

In preparation for the taking of samples, locate a portable fan so that the working area will be well ventilated as the sample is being drawn. Only qualified personnel should proceed in performing the sampling procedure. They should protect themselves from direct contact with ammonia when taking samples and performing the tests. Protective hats, glasses, gloves, and clothing should be worn as personal protective equipment (PPE). A source of water should be nearby.

X. Percent of Water by Weight

The formula for the percent of water by weight referenced in Section VII, Water Percentage Determination, is derived as follows:

1. Determine the weight of the initial sample.

   Weight (grams) = ml of sample x 0.683 grams/ml (density of anhydrous ammonia at -28° F)

   = ml of sample x 0.683

2. Determine the weight of the ammonia removed from the system.

   $$\text{Weight (grams)} = \frac{\text{weight of the initial sample}}{\text{Evaporation Factor (EF)}}$$

   $$= \frac{\text{ml of sample x 0.683}}{\text{EF}} \quad \text{or} \quad \text{ml of sample x 0.683/EF}$$

3. Determine the weight of water in the residue solution.

   Weight (grams) = ml of residue x 0.892 (density of a 30% ammonia solution) x 0.70 (residue solution 70% water)

   = ml residue x 0.892 x 0.70

   = ml residue x 0.624

4. $$\text{Percent water by weight} = \frac{\text{weight of water in residue}}{\text{weight of ammonia removed from system}} \text{ x 100}$$

   $$= \frac{\text{ml residue x 0.624}}{\text{ml sample x 0.683/EF}} \text{ x 100}$$

$$= \frac{\text{ml residue} \times 0.914 \times \text{EF}}{\text{ml sample}} \times 100$$

Appendix D. (Informative) Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock

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I. Preface

Refrigeration system component designs incorporate safety factors well above normal system working pressures. However, all systems are subject to conditions created by design, operation, or service that can result in excessive pressures within the closed-circuit refrigeration system. These pressures release static and kinetic energy that may damage evaporators, valves, pressure vessels, or piping causing a release of refrigerant that could lead to possible product loss or personal injury.

The scope of this informative appendix is to provide voluntary guidelines and recommendations for avoiding component failure in industrial refrigeration systems that may be caused by abnormal pressure or shock, also known as hydraulic shock. Existing systems may not have considered or implemented design methods, such as those specified in ANSI/IIAR 2, to avoid component failure caused by abnormal pressure or shock as an integral part of the system's original design. For safety, it is crucial that all refrigeration systems be on alert and are routinely checked for onset indications of abnormal pressures and hydraulic shock. Indications identified at the onset can address the root cause situations and avoid component failure that could otherwise lead to risks of injury, equipment damage, or both. The recommendations contained in this informative appendix are intended for systems using ammonia as the refrigerant. However, the principles involve may apply to industrial refrigeration systems using other refrigerants.

II. Hydraulic Shock

Hydraulic shock is a sudden localized spike in pressure that can occur in piping or equipment when there is a rapid change in velocity of a flowing liquid. This is often referred to as "liquid hammer".

Hydraulic shock in refrigeration systems can generate extreme high pressures with the potential to cause the catastrophic failure of piping, valves, and other equipment. The highest pressures often occur when vapor and liquid refrigerant are present in a single pipe line and are disturbed by a sudden change in volume.

Moderate hydraulic shocks can generate pressures that are evidenced by indicating knocking sounds emanating from piping and valves that are trying to release kinetic energy (i.e., liquid hammer). These hydraulic shocks will actually try to move the piping, valves, or equipment. Visual indications may be seen when pipe hangers have tried to shift, bend, or the piping shows scratches and marks from the hangers rubbing on the piping themselves.

Three (3) common disturbance mechanisms can result in hydraulic shock in refrigeration systems which are as follows:

1) Sudden Liquid Deceleration – Caused by the rapid closing of a valve in a pipe carrying flowing liquid. When the flow of liquid stops suddenly, a spike of pressure within the valve body and connected piping occurs.

2) Vapor-Propelled Liquid Slug – Caused by high-pressure vapor flowing in a line partially filled with liquid that entrains a sufficient volume of liquid to fill the pipe circumference, thereby creating a liquid "slug". These liquid "slugs" move rapidly until they encounter an obstruction such as a valve or pipe end-cap. Momentum from the flowing liquid is imparted to the obstructing component resulting in a rapid rise in pressure or hydraulic shock.

3) Condensation-Induced Shock – Caused when high pressure refrigerant vapor rapidly condenses in pipe lines containing both liquid and vapor. As ammonia vapor condenses, it undergoes a large decrease in volume. This large reduction in volume causes liquid to accelerate. When the accelerated liquid encounters adjacent obstructions, such as valves, pipe end-caps, or even equipment, it attempts to move and damage the obstruction.

Damaging hydraulic shock events are typically the condensation-induced type and frequently can occur in low-temperature ammonia refrigeration systems. These events are often associated with the transition from high temperature and pressure to low temperature and pressure during and after the defrosting of evaporators with hot gaseous refrigerant.

A combination of both condensation-induced shock and vapor-propelled liquid often occur during a hydraulic shock.

Damaged system components could be evaporators, associated valves, suction piping and suction header mains downstream of the evaporators, including the pipe end-caps. Undesirable transient events can occur in piping that are conveying both liquid and vapor.

III. Trapped Liquid

Although not a hydraulic shock, which is a kinetic energy risk where the refrigerant as a vapor, liquid or both is moving, a hydrostatic lockup is a static energy risk that can occur when liquid refrigerant is trapped and not moving. Trapped liquid is the complete filling of the internal volume of a containment envelope, such as a pressure vessel or pipe, with liquid refrigerant. As temperature and pressure proportionately change, rising temperatures lead to increases in internal component pressure. The increasing internal pressure of the trapped liquid places its rising force against all the internal surfaces of the pressure containing envelope causing the containment area to increase in volume. An increase in volume of liquid ammonia at -40°F (-40°C) is about 1% for each 10°F (5.6°C) increase in temperature.

Failures of the pressure containing envelope can occur when the rising force thermally expands the component beyond its designed material strength until it ruptures.

Trapped liquid is most frequently caused by the improper closing of hand valves that trap liquid in confined space. This typically can occur during an isolation procedure while servicing a component in a liquid line.

Examples of this include trapping of liquid between two hand valves or between a check valve and a downstream hand valve.

Before servicing a control valve or other components in a liquid line, the liquid from both sides of the device(s) should be removed. A hand valve on the inlet side should be closed first and the liquid removed (i.e., evacuated or pumped out) from the component and its downstream side. Only then should the downstream side or suction be closed off, thereby isolating the component from the closed-circuit system.

An evaporator that is full of liquid refrigerant should not be isolated. If isolation is necessary, the evaporator must be pumped out first. An evaporator located in a cold area may take several hours for a total pump out.

ANSI/IIAR 2 provides design requirements for overpressure protection to prevent buildup of excessive hydrostatic pressure caused by trapped liquid. For minimum safe design requirements, see ANSI/IIAR 2. For minimum safe installation requirements, see ANSI/IIAR 4. For startup, see ANSI/IIAR 5. For developing an operating procedure, see ANSI/IIAR 7.

IV. SUDDEN LIQUID DECELERATION

Sudden liquid deceleration is similar to liquid hammer (i.e., water hammer) in a water distribution system that does not have shock absorbing air pockets in the piping at the location of each shut-off valve. Simple vapor pockets in a liquid refrigerant system cannot be relied upon to provide the same protection because the refrigerant vapor will tend to condense, filling the pockets with liquid.

Sudden liquid deceleration can be caused by flow in a liquid line that is suddenly stopped by a snap acting solenoid valve. However, the design flow velocities and pressures in the liquid lines of overfed systems are normally too low to produce shocks of any significance.

The next revision of ANSI/IIAR 2 will contain suggestions which can be implemented if sudden liquid deceleration is detected in an existing system.

V. VAPOR-PROPELLED LIQUID SLUG and CONDENSATION-INDUCED SHOCK

Nearly all industrial refrigeration systems are safe and function, under normal circumstances, without problems resulting from high velocity liquid propelled by high-pressure vapor. However, abnormal and unusual conditions can result in trouble in a system where neither the design nor operating procedures have anticipated these problems.

Most reported vapor propelled liquid problems occur in low temperature systems with components operating a -20°F (-29°F) or colder refrigerant, employing liquid overfeed and using hot gas defrost. Air, electric, and secondary coolant (i.e., glycol, brine) sprayed defrosting techniques tend to be less stressful than hot gas defrosts on low temperature evaporators.

Vapor propelled liquid can be caused by the sudden release of a high-pressure vapor, such as hot gas, into a line that is partially filled with liquid.

Condensation-induced shock can be caused when high pressure refrigerant vapor rapidly condenses in piping containing both liquid and vapor. As the ammonia vapor condenses, it undergoes a large decrease in volume. This large reduction in volume causes liquid to accelerate. When the accelerated liquid suddenly encounters adjacent obstructions, such as valves, pipe end caps, or even equipment, it attempts to move and damage the obstruction from the increased pressure.

A combination of both condensation-induced shock and a vapor propelled liquid slug often occur during a “Hydraulic Shock” event.

Following are examples of where a combination can develop and result as a hydraulic shock:

a. A hot gas line containing some condensed liquid, that is intended to defrost one or more evaporators, is introduced with hot gas.

b. The sudden release of both pressurized liquid and vapor from a defrosted evaporator into a trapped or incorrectly sloped wet suction line. Because sudden gas releases can reach velocities of 100 ft/s (30 m/s), the resulting impact pressure produced by a liquid slug can exceed 3,000 psig (21,000 kPa).

Abnormal shocks to a system caused by vapor propelled liquid are accompanied by external symptoms. These include abnormal load sounds (e.g., such as bangs and thumps), moving pipes, and moving evaporators. Pressure gauge needles may also be pinned beyond their stop. Insulation may come loose, and refrigerant leaks may start. If the first shock does not result in a leak or rupture, repeated shocks can eventually lead to a failure.

V.1. Liquid in Hot Gas Lines

The most common way to defrost industrial refrigeration evaporators is with the use of hot gas. Mismanagement of hot gas usage can cause vapor propelled liquid problems and possible system failures. The most significant problem is the condensation of liquid inside a hot gas line. This condensation itself can result as a condensation-induced shock or set the stage to become a combination event with vapor-propelled liquid resulting as a slug.

When defrosting occurs, a hot gas valve opens and high-pressure vapor rapidly moves through the pipe line. The high velocity flow of this vapor will pick up any liquid lying it its path and push it ahead of the vapor until it is stopped.

Laboratory tests which duplicate high velocity liquid slugs in a hot gas line have shown that pressures in excess of 2,000 psig (14,000 kPa) can be developed. These excess pressures can blow off pipe end-caps and rupture coil headers without deforming them first.

When using hot gas for defrosting, it is important that the condensed liquid be removed from the hot gas line. All condensation in hot gas lines cannot be prevented, but where condensation may occur, adjustments could be made to minimize the condensation.

V.2. Initiation of Hot Gas Defrost

The potential for shock is strong at the initiation of hot gas defrost when an evaporator is suddenly changed into a condenser. Abnormal pressure or shock can be eliminated if the change in pressure is applied in a gradual manner. This is particularly important if there is excessive liquid in the evaporator or it is completely full of liquid.

If the incoming hot gas contains liquid which was condensed in the hot gas line and was not removed, the shock effect from vapor propelled liquid can be very destructive to the evaporator coil. The header pipe-end caps could blow off or headers and return bends could split.

If the evaporator is full of liquid as a result of prolonged light load operation, this hammer-like shock can create a compression wave in the stationary liquid producing pressures in the 1,000 to 2,000 psig (7,000 to 14,000 kPa) range, resulting in severe damage. Therefore, it is important to keep the hot gas pressure as low as possible, consistent with defrost and plant requirements.

The next revision of ANSI/IIAR 2 will contain recommendations for minimizing the potential for shock at the initiation of a hot gas defrost.

V.3. Termination of Hot Gas Defrost

As with hot gas defrost initiation, the potential for shock is also high at the termination of hot gas defrost, when a condenser is suddenly changed into an evaporator. The change in pressure must be gradual because liquid is present in the coil and in liquid overfeed suction lines.

The gradual release of defrost pressure into the suction line is equally important for flooded or liquid overfeed evaporators. For flooded systems, a defrost reseating relief regulator with an electric full-opening feature can be used to bleed down the evaporator by energizing the full-opening pilot solenoid valve.

The next revision of ANSI/IIAR 2 will contain recommendations for minimizing potential for shock at the termination of a hot gas defrost.

V.4. Light and No-Load Conditions

Evaporators that have a constant load are rare. Variations in production rates, stopping of conveyor lines, changes in outdoor temperatures, cycling of evaporator fans, and changes in suction pressures are common events that will change the load on an evaporator.
detector
If an evaporator defrost is incomplete, each subsequent defrost will leave additional ice on the coil. The capacity of the evaporator will continue to drop because of the insulating effect of the ice. Thus, it is possible for an evaporator to become completely filled with liquid while operating under light and no-load conditions.

If hot gas defrosting is initiated on a liquid overfeed evaporator that has been operating under very light load conditions for an extended period of time, the evaporator will be very vulnerable to shock due to vapor propelled liquid.

VI. Operating System's Emanating Sounds - Normal or Abnormal?

It is not always easy to duplicate an abnormal pressure or shock situation during "normal" operating conditions because these incidents frequently occur during light load periods such as nighttime, weekends, or holidays. However, the emanating sounds an operating refrigeration system makes are often an important factor in determining if the system is operating properly. A qualified operator who has become familiar with an operating refrigeration system(s) can recognize the difference between normal and abnormal emanating sounds.

For example, the emanating sounds an evaporator makes as it sequences through a hot gas defrost cycle should be minimal. Loud emanating sounds such as thumps, bumps, slams, thuds, and clunks, are not normal and the qualified operator should recognize these abnormal sounds and take steps to eliminate the causes.

The extremely high-pressure spikes created by sudden liquid deceleration or vapor propelled liquid are so brief that a relief valve or regulator cannot respond quickly enough to make any difference. However, pressure gauge needles do move and get jammed beyond their stop and will stay in that position. Jammed gauge needles may indicate the presence of unusually high pressure at the location of the gauge. Flange bolts that repeatedly require tightening may also be indicators of excessive pressures.

Caution must be taken to ensure proper defrost procedures and the correct handling of valves to prevent abnormal pressure of shock failures. Whenever abnormal emanating sounds are heard or piping is moving, the qualified operator must be suspicious of a condition that may exist that will lead to component failure. Inspection of pressures and a check for abnormal emanating sounds at all the evaporators during a defrost cycle should be a regular part of the maintenance routine requirements.

Appendix E. (Informative) Risk-based Inspection, Testing, and Maintenance

The overall objective of inspection, testing, and maintenance (ITM) practices are to sustain reliability to increase the profitability of the operation and optimize the total life cycle cost without compromising safety or environmental issues. Risk assessment integrates reliability with safety and environmental practices and can be used as a decision tool for predictive and preventive maintenance planning strategies.

Unexpected failures usually have adverse effects that can lead to an unsafe or environmental hazard. There is a close relationship between ITM practices and the resulting reliability of equipment and systems. To maximize equipment and system availability and efficiency, to control equipment and system deterioration, to ensure a safe and environmentally friendly operation, and to minimize the total cost of the operation, a strategy with ITM practices should be implemented. ITM management techniques that adopt a structured risk-based ITM strategy can further provide optimization. A risk-based ITM strategy can be cost effective for operations and minimize or prevent hazards, both to humans and the environment, caused by unexpected equipment or system failures.

A risk-based ITM strategy includes the study and risk ranking of equipment and system failures based on probability (likelihood) and consequence (severity). The risk-based assessment learnings are used as criteria to further enhance the development of ITM tasks for the equipment and systems for planning, implementing, and optimizing results. The risk-based assessment is a technique for identifying, characterizing, quantifying, and evaluating loss from an event. It integrates probability and consequence analysis at various stages of the assessment. In this context, risk can be defined for a particular failure scenario as the following:

Risk = Probability of failure x Consequence of the failure

At a minimum, the risk assessment, which can be qualitative or quantitative, should have its methodology include the following:

1) A risk determination, which consists of risk identification and estimation.
2) A risk evaluation, which consists of risk aversion and risk acceptable analysis.
3) ITM task planning considering risk factors.

Reducing the level of risk or eliminating the risk is the objective of the risk-based ITM developed practices. The risk ranking is used to optimize ITM task intervals and to plan predictive and preventive practices based on site-acceptable risk levels and operating limits, while mitigating risks as appropriate.
The risk ranking is similar to a Process Safety Management (PSM) Process Hazard Analysis (PHA), but also includes the review of the site's historical PHA's in the risk assessment.

Inspections typically can lead to and employ non-destructive testing (NDT) and the results lead to maintenance services to correct, eliminate, and/or recondition the equipment and systems for its sustainability.

The following references are suitable guidelines for ITM content development for a Risk-Based Program:

American Society of Mechanical Engineers (ASME), *Risk-Based Inspection-Development of Guidelines: General Document: Volume 1* (1991) ISBN 9780791806180

American Society of Mechanical Engineers (ASME), PCC-3 *Inspection Planning Using Risk-Based Methods* (2007)

Appendix F. (Informative) References and Sources of References

F.1 Informative References

F.1.1 ASME (American Society of Mechanical Engineers). (2023). *Boiler and Pressure Vessel Code, Pressure Vessel, Section VIII, Division 1*. New York.

F.1.2 ASME (American Society of Mechanical Engineers). (2022). *Inspection Planning Using Risk-Based Methods,* PCC-3. New York.

F.1.3 ASME (American Society of Mechanical Engineers). (2022). *Refrigeration Piping and Heat Transfer Components*, B31.5. New York.

F.1.4 ASME (American Society of Mechanical Engineers). (1991). *Risk-Based Inspection-Development of Guidelines: General Document: Volume 1*. New York.

F.1.5 EPA (Environmental Protection Agency). 40 CFR Part 68, *Chemical Accident Prevention Provisions.* Washington, DC.

F.1.6 EPA (Environmental Protection Agency). *General Duty Clause in Section 112(r)(1), Clean Air Act.* Washington, DC.

F.1.7 IIAR (2005). *Ammonia Refrigeration Management Program* (ARM) (2018).

F.1.8 IIAR (2021). *Standard for Design of Safe Closed-Circuit Ammonia Refrigeration Systems*, IIAR 2, Alexandria, VA.

F.1.9 IIAR (2020). *Installation of Closed-Circuit Ammonia Refrigeration Systems,* IIAR 4. Alexandria, VA.

F.1.10 IIAR. (202x). *Startup of Closed-Circuit Ammonia Refrigeration Systems,* IIAR 5. Alexandria, VA.

F.1.11 IIAR. (202x). *Developing Operating Procedures for Closed-Circuit Ammonia Refrigeration Systems,* IIAR 7. Alexandria, VA.

F.1.12 IIAR. (2020). *Process Safety Management & Risk Management Program Guidelines*. Alexandria, VA.

F.1.13 ISEA (International Safety Equipment Association). [2014 (R2020)]. ANSI/ISEA Z358.1, *World Safety Standard for Emergency Eyewash and Shower Equipment.* Arlington, VA.

F.1.14 OSHA (Occupational Safety and Health Administration). 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals.* Washington, DC.

F.1.15 OSHA (Occupational Safety and Health Administration). *General Duty Clause in Section 5(a)(1) of the Occupational Safety and Health Act* [29 U.S.C. § 654(a)(1)]. Washington, DC.

F.2 Sources of References

F.2.1 American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036, USA
www.ansi.org

F.2.2 American Society of Mechanical Engineers (ASME)
ASME International
Two Park Avenue
New York, NY 10016-5990, USA
www.asme.org

F.2.3 International Institute of All-Natural Refrigeration (IIAR)
1001 North Fairfax Street
Suite 503
Alexandria, VA 22314, USA
www.iiar.org

F.2.4 International Safety Equipment Association (ISEA)
1901 North Moore Street
Suite 808
Arlington, VA 22209-1762, USA
www.safetyequipment.org

F.2.5 Occupational Safety and Health Administration (OSHA)
United States Department of Labor
Washington, DC 20210, USA
www.osha.gov
www.dol.gov
www.osha.gov/tdc

F.2.6 United States Environmental Protection Agency (EPA)
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460, USA
www.epa.gov

