American National Standard for

ANSI/IIAR 5-2013

Start-up and Commissioning of Closed Circuit Ammonia Refrigeration Systems

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iiar®
International Institute of Ammonia Refrigeration

IIAR 5

Start-up and Commissioning of Closed-Circuit Ammonia Mechanical Refrigerating Systems

International Institute for Ammonia Refrigeration
1001 North Fairfax Street, Suite 503
Alexandria, VA 22314
Phone: (703) 312-4200
Fax: (703) 312-0065
www.iiar.org

Notes on the Standard Text

Metric Policy

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

Normative/Informative Elements

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

Notice

The information contained in this Standard 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 document, or that additional measures may not be required under certain circumstances or conditions. The Standards Committee and Consensus Body that approved the Standard were balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed Standard was made available for review and comment for additional input from industry, academia, regulatory agencies and others.

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Foreword (Informative)

This Standard specifies minimum criteria for the start-up and commissioning of ammonia mechanical refrigerating systems. Additional requirements may be imposed by particular circumstances, system design, or jurisdictional considerations. This document reflects the consensus reached by ammonia refrigeration industry representatives and is not a comprehensive task list for start-up and should not be used in that manner.

For the purposes of this Standard, it is assumed that the refrigerating system has been designed for the duty that it is to perform, that all piping and electrical equipment has been installed and that adequate connections for the start-up and test instruments have been provided. Since this document defines the minimum requirements for the start-up and commissioning of ammonia mechanical refrigerating systems, it may not be sufficient to meet other standards and/or regulations that are applicable to each specific refrigerating system. Accordingly, additional requirements may be necessary because of particular circumstances, project specifications or other jurisdictional considerations. The International Institute of Ammonia Refrigeration (IIAR) Process Safety Management Guidelines for Ammonia Refrigeration and Risk Management Program Guidelines for Ammonia Refrigeration address the additional requirements needed to meet United States regulations. Note that this proposed Standard does not constitute a comprehensive, detailed technical manual and should not be used as such.

Experience shows that ammonia is very difficult to ignite and is very stable under normal conditions. The ignition point of ammonia is limited to a range of 160,000 ppm to 250,000 ppm. This concentration far exceeds the 50 ppm permissible exposure level published by OSHA.

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

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

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

At the time of publication of this Standard for the Start-Up and Commissioning of Closed-Circuit Ammonia Mechanical Refrigerating Systems, the IIAR Standards Committee had the following members:

Ron Worley – Nestlé USA
Dave Schaefer – Bassett Mechanical
Joseph Pillis – Johnson Controls
Peter Jordan – MBD Risk Management Services, Inc.

The task group for this standard had the following members:

Dennis Carroll – Johnson Controls, IIAR 5 Subcommittee Chair
Don Faust – Gartner Refrigeration & Mfg., Inc.
Eric Brown – ALTA Refrigeration, Inc.
Jeff Sutton – Sutton and Associates, Inc.
Brian Marriott – Marriott & Associates

Table of Contents

Section 1

Purpose

This Standard specifies criteria and procedures for start-up and commissioning of closed-circuit ammonia mechanical refrigerating systems.

Section 2

Scope

2.1 This Standard provides basic minimum requirements for the safe start-up and commissioning of completed closed-circuit mechanical refrigerating systems utilizing ammonia as the refrigerant and to additions and modifications made to such systems. The specific requirements for a particular system shall be considered when applying the general recommendations expressed in this Standard.

2.2 Start-up and commissioning shall be performed, at a minimum, in accordance with equipment manufacturer's instruction manuals. This standard focuses on practices that promote safety.

2.3 This standard refers to those parts of a refrigerating system that are in contact with ammonia.

2.4 Unless otherwise noted, it is the responsibility of the owner or the owner's representative to obtain or otherwise arrange for the completion of all requirements in this Standard. It is permissible for the owner or the owner's representative to delegate this responsibility by contract.

Section 3

Definitions

Refer to ANSI/IIAR 1-2012 for Definitions.

Section 4

References

4.1 Normative References

4.1.1 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE), ANSI/ASHRAE 15-2010, *Safety Standard for Refrigeration Systems*

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

4.1.3 International Institute of Ammonia Refrigeration (IIAR), ANSI/IIAR 2, latest edition, Equipment, *Design and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*

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

4.1.4.1 29 CFR Part 1910.119, *Process Safety Management of Highly Hazardous Chemicals*

4.1.4.2 29 CFR Part 1910.132, *General Requirements, Personal Protective Equipment*

4.1.4.3 29 CFR Part 1910.133, *Eye and Face Protection*

4.1.4.4 29 CFR Part 1910.134, *Respiratory Protection*

4.1.4.5 29 CFR Part 1910.146, *Permit-Required Confined Spaces*

4.1.4.6 29 CFR Part 1910.147, *The Control of Hazardous Energy* (lockout/tagout)

4.1.4.7 29 CFR Part 1910.219, *Mechanical Power Transmission Apparatus*

4.1.4.8 29 CFR Part 1910.252, *General Requirements, Welding, Cutting and Brazing*

4.1.5 Environmental Protection Agency (EPA), 40 CFR 68, Chemical Accident Prevention Provisions.

4.1.5.1 Clean Air Act Section 112(r)(1), General Duty Clause

4.2 Informative References

4.2.1 International Institute of Ammonia Refrigeration (IIAR):

4.2.1.1 IIAR Poster P-1, *Ammonia Mechanical Refrigeration Systems & Safety Practices and First Aid*

4.2.1.2 IIAR *Ammonia Data Book*

4.2.1.3 IIAR White Paper, *Ammonia: The Natural Refrigerant of Choice*

4.2.1.4 Compressed Gas Association CGA G-2, 1995

Section 5

General Ammonia Information

5.1 Specification

5.1.1 Refrigerant-grade anhydrous ammonia that meets or exceeds the minimum requirement of Compressed Gas Association CGA G-2, 1995, (ref. 4.2.2) shall be used for the initial charge and subsequent top-off (fill the system to the operating intended inventory) of all ammonia refrigerating systems.

5.1.2.1. A grade specifying less than 99.95 percent ammonia shall not be used.

5.1.2.2 The material shall be a clear colorless liquid free from visible impurities.

5.1.2.3 Purity requirements are shown in Table 1.

Table 1. Purity Requirements

Ammonia Content	99.95% Min.
Non-Basic Gas in Vapor Phase	25 ppm Max.
Non-Basic Gas in Liquid Phase	10 ppm Max.
Water	33 ppm Max.
Oil (as soluble in petroleum ether)	2 ppm Max.
Salt (calculated as NaCl)	None
Pyridine, Hydrogen Sulfide, Naphthalene	None

5.2 Physical Properties

5.2.1 The following IIAR publications contain additional information on this topic: ANSI/IIAR 2, Latest edition (ref. 4.1.3), Ammonia Data Book (ref. 4.2.1.2).

5.3 Precautions and Hazards

5.3.1 Ammonia refrigerating system operating personnel shall be trained in the proper handling of ammonia and familiar with its dangers. The following IIAR publications contain additional information on this topic: IIAR 2, Latest edition (ref. 4.1.3); Poster P-1 *Ammonia Mechanical Refrigeration Systems & Safety Practices and First Aid* (ref. 4.2.1.1); Ammonia Data Book (ref. 4.2.1.2); IIAR White Paper: *Ammonia: The Natural Refrigerant of Choice* (ref. 4.2.1.3)

Section 6

Records

6.1 Design Records

6.1.1 The ammonia refrigerating system shall have been designed by, and installed under the supervision of, persons who by reason of knowledge, training and experience are competent for the tasks. Such persons typically include:

a. experienced refrigeration contractors, possibly in combination with a code authority, authorized inspection agency or property insurance underwriter

b. in-house design/engineering staff of the owner or the owner's designated representative

c. consulting engineers, acting on behalf of the owner or the owner's designated representative

d. refrigeration equipment suppliers.

6.1.2 Records and documentation relevant to the system shall be obtained and maintained by the owner in a safe place and be readily available for examination so that the standards and details to which the system was designed are available to those concerned with inspection, maintenance and operation.

6.1.3 The records shall contain a schematic refrigeration circuit P&ID and/or a refrigeration flow diagram for the refrigerating system. The system designer, contractor and/or owner shall determine which controls and valves may be the most likely to be of importance in an emergency. These controls and valves shall be clearly identified on the diagram which shall be updated when changes are made to the system. These controls and valves shall also be uniquely identified on the actual system.

6.2 System Component Inventory List

6.2.1 A system component inventory list shall be prepared. The list shall include the major components of the ammonia refrigerating system, including: compressors, condensers, evaporators, pressure vessels, liquid ammonia pumps, piping, valves and fittings, ammonia machinery room ventilation system, and other control and safety devices.

For each system component included on the inventory list, the specifications and details from the following shall be included in the records:

a. physical description

b. name plate data in accordance with the governing edition of IIAR 2 (ref. 4.1.3)

c. test and fabrication certificates, where applicable

d. pressure-relief devices, type and set pressure, date of installation/replacement (if externally installed)

e. manufacturer's instruction manual

f. materials of construction

g. electrical classification

h. piping and instrumentation diagrams

i. pressure-relief discharge piping system design and design basis

j. design codes and standards employed

k. safety systems including safety devices, interlocks, switches, and detectors

year of construction or date of modification.

In addition the following items from the inventory list require the additional records indicated:

m. piping network

   i) pressure test verification in accordance with ASME B31.5, latest edition, Refrigeration Piping and Heat Transfer Components (ref. 4.1.2)

   ii) design pressure / design temperature

n. ammonia machinery room ventilation systems

ventilation air flow diagrams

ventilation control system description

o. control and safety devices

ammonia vapor detection system

initial calibration record

p. designed ammonia charge

6.2.2 The inventory list shall contain a record of the maximum working pressure(s) and minimum temperatures as applicable.

6.3 Field Pressure Test Records. Records shall be kept of these tests. These tests shall be completed before the refrigeration system is charged with ammonia.

Section 7

Start-Up of New Installations

7.1 General

A typical procedure to be followed during start-up is given below for guidance, but it is emphasized that the procedure may need to be tailored to suit the scope of new work, equipment, location and duty of the specific refrigerating system. This standard shall be used to establish the minimum criteria of a system's initial start-up standard operating procedure.

NOTE: A successful ammonia refrigeration system start-up requires a team approach with careful planning early in the construction process. Timing, roles and responsibilities need to be coordinated among all stakeholders. Engineers, system designers, owners, operators, manufacturers, suppliers, and contractors are all stakeholders and have a part in the process.

Ammonia facilities to be operated in the United States are subject to OSHA and EPA regulations. Systems that will contain the federal or state threshold quantity of ammonia will be subject to OSHA's Process Safety Management (PSM) and the EPA's Risk Management Plan (RMP). Systems that will contain less than established threshold quantities will not be subject to PSM and RMP, but be will be subject to both agencies' General Duty Clauses. Therefore any facility that will use ammonia must have a refrigerant management plan in place prior to charging a system with ammonia. The EPA also requires (Tier1 or Tier 2) reporting of systems that contain minimum established threshold quantities that are less than the PSM and RMP threshold. Owners are responsible for ensuring that employees and/or contractors are aware of regulations and are compliant with them. Agreements shall be established regarding the provision of information and training required for a facility's refrigeration management plan. Agreements shall be established regarding who is responsible for the system during construction and start-up, and at which point the owner becomes solely responsible for safe practices.

7.2 Hazard Review

In the United States, ammonia refrigeration systems that are subject to OSHA's PSM Regulation and the EPA's Risk Management Program Regulation shall have a formalized Process Hazard Analysis performed prior to the addition of anhydrous ammonia to the new system. Ammonia refrigeration systems that do not meet the threshold quantity set forth by OSHA's PSM Regulation and the EPA's RM Program Regulation should also be analyzed by performing a formalized Process Hazard Analysis prior to the addition of anhydrous ammonia to the new system in an effort to comply with OSHA's and the EPA's General Duty Clause requirements. OSHA and EPA have outlined acceptable Hazard Analysis techniques that can be utilized for the performing of the hazard analysis; additionally, IIAR's Ammonia Refrigeration Management Program contains checklists that can be utilized for the hazard analysis. The owner shall confirm that the hazard review has been completed and that the recommendations requiring closure prior to start-up have been resolved. The owner shall also confirm that the hazard review is available to the operators responsible for operating the process."

7.3 Pre-Charging Safety Review

Prior to charging refrigeration grade ammonia (see 5.1) into the refrigeration system, the designated trained start-up technician shall confirm that personnel and equipment are ready. An example of a Pre-charging Check List is provided in Appendix D. All Pre-charging Check List items shall be confirmed in accordance with OSHA regulation 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals (ref. 4.1.4.1).

7.4 Pre-Start-up Safety Review

Prior to starting the system for the first time, a Pre-Start-up Check List shall be completed. Some Pre-Start-up Check List items are listed in Appendix D.

7.5 Operating Procedures

7.5.1 The owner or the owner's designated representative shall:

a. confirm that operating procedures are complete and address steps for each operating phase, and

b. ensure that the operating procedures include operating limits, safety and health considerations, and safety systems and their functions, and

c. provide the individual responsible for the start-up all operating procedures prior to commencing charging and start-up of the system.

7.5.2 The operating procedures shall be readily accessible to the employees who work on or with the refrigeration system. The owner or the owner's designated representative shall certify that the operating procedures are current and accurate. Safe work practices shall be implemented such as:

a. OSHA regulation 29 CFR 1910.147, The Control of Hazardous Energy (lockout/tagout) (ref. 4.1.4.6)

b. OSHA regulation 29 CFR 1910.146, Permit-required Confined Spaces (ref. 4.1.4.5)

c. OSHA regulation 29 CFR 1910.252, Hot Work Fire Prevention and Protection (ref. 4.1.4.8)

d. control of entrance into the facility.

7.6 Training

The owner or the owner's designated representative shall verify that training has been completed for the following items and personnel:

a. Employees involved in operating the refrigerating system shall be trained in an overview of the process and the operating procedures. The training shall include safety and health hazards, emergency operations and safe work practices. The training shall be documented and it shall be verified that the employees understood the training.

Employees who are designated to maintain the on-going integrity of the system and equipment that is connected to the system shall be trained in an overview of the process and its hazards. The training shall include the procedures applicable to the employees' tasks.
c. Employees involved in the emergency plan or the emergency response shall be properly trained to fulfill their duties in this regard.
d. A trained start-up technician shall be designated by the owner or the owner's representative and assigned responsibility of the start-up and commissioning process.

7.7 Delivery of Information

7.7.1 Prior to initial start-up and commissioning of the system, the supplier of the equipment, the design firm and the installing contractor shall deliver to the owner or the owner's representative all documentation and records relevant to the design, maintenance, working pressure and safety aspects of the system.

Such information may include:
a. a manual containing operating instructions, recommended spare parts list, etc.
b. a refrigerating system drawing
c. a starting and stopping procedure, including emergency stop instructions
d. stopping procedure for prolonged shut-down
e. details of safety procedures to be used in the event of an emergency
f. recommended list of oils and lubricants to be used and recommended frequency of change.

In addition, the trained start-up technician shall deliver all data to the owner or owner's representative that has been compiled during the start-up and commissioning. Such data shall include a comprehensive log taken during the test period to ensure that a benchmark for operation is available for future reference by the operating staff.

7.7.2 The owner or the owner's representative has a duty to arrange instruction for the operating staff so that the system can be operated and maintained safely. Subject to agreement with the owner or the owner's designated representative, this instruction may be provided by the trained start-up technician or other representative of the installer.

7.8 Initial Status and Safety Provisions

7.8.1 Before the system is charged with ammonia, it shall be verified by the owner or the owner's designated representative that the machinery room and any other spaces containing parts of the system and access thereto have been designed and built in accordance with the requirements of the governing edition of IIAR 2 (ref. 4.1.3) and other applicable codes and standards. These spaces shall have been cleared of all portable equipment and obstructions that could impede egress in the event of an emergency. Emergency lighting, exit signs, fire extinguishers or sprinklers and ventilation fans shall be ready for operation. Required first aid and safety equipment shall be readily available. For further guidance on the requirements in relation to machinery rooms and safety equipment, see Appendix B.

7.8.2 The owner or the owner's designated representative shall ensure that eye wash and deluge shower facilities are available. The owner or the owner's designated representative shall ensure the technicians involved with start-up have been provided with appropriate training on the use of PPE (personal protective equipment). PPE shall be carefully and safely stored and shall be readily available in the vicinity of the installation. During start-up, one respirator or SCBA (Self Contained Breathing Apparatus) shall be available immediately outside the area where start-up is taking place, with an additional respirator or SCBA safely stored but available as above (these may form part of the permanent safety equipment identified in the facility's refrigeration management program or be brought in specifically for start-up).

7.8.3 Before any ammonia closed-circuit mechanical refrigerating system is charged and put into service the owner or the owner's representative shall confirm that the local emergency authorities and all applicable authorities having jurisdiction are aware that ammonia is used or is to be used at that location.

7.8.4 Notice shall be given to ensure that all personnel on the site are aware that the system is about to be charged with ammonia and that the area in which the machinery room and charging equipment is located will become an area closed to unauthorized persons.

7.8.5 The trained start-up technician shall review the installation of the refrigerating system and associated equipment with those responsible for its installation. A procedure for communication with those responsible for the installation and the trained start-up technician shall be established.

7.8.6 Prior to commencement of start-up, a visual inspection shall include, but not be limited to, all piping, electrical wiring, supports, covers and guards to insure the system is in proper order.

7.8.7 Some components of the refrigerating system such as evaporators, evaporative condensers and receivers may be remotely located or outside of the machinery room. These remote components and associated piping and controls shall be included in all specified inspections. Note: The equipment checklist in Appendix D may be used for guidance to conduct the inspections.

7.8.8 Operational and System Emergency Devices

The following shall be exercised and proven operational before ammonia is introduced to the system:
Normal Ventilation
Emergency Ventilation
Emergency Shut-Down Button(s)
Any Automatic Emergency Isolation Valve(s)
Deluge Shower/Eyewash
Refrigerant Detectors

All shutdown and alarm devices shall be tested for operation and function at the specified setting. Any device out of range or that fails to function properly shall be adjusted, recalibrated or replaced.

7.9 Electrical Equipment

7.9.1 Before a system is started up, it shall be visually inspected by the owner or the owner's designated representative. The owner or the owner's designated representative shall verify electrical wiring is correct and properly supported, the control panel(s) has been inspected both internally and externally, and that all specified equipment has been correctly installed and that all fuses or circuit breakers installed in the panel(s) are of the correct rating, as indicated in the specification.

7.9.2 Before any electrical supply is connected to any part of the electrical control system, the trained start-up technician shall witness a test of all cables and wiring to ensure that no faults exist or receive an appropriate test certificate that certifies the same.

7.9.3 All main drive motor, pump and auxiliary equipment shall be isolated from their source of power. Only the control circuit shall be energized for testing.

7.9.4 While power is applied to the control circuit, all control points shall be tested to ensure they receive the correct signal or input.

7.9.5 While isolated from their source of power, the coupling or V-belts between the prime mover(s) and the compressor(s) shall be disconnected; the equipment shall be rotated by hand to ensure that it turns freely.

7.9.6 Power shall be applied to auxiliary equipment drives and these shall be tested for direction and operation. Initial overload settings shall be those shown on the motor nameplate. Once the system has obtained its design operating conditions, the motor overload settings may be adjusted to reflect these conditions.

7.9.7 Power shall be applied to the main drive motor(s) and the motor(s) rotated electrically and checked for direction. In certain cases it may be necessary to bypass electrical interlocks in order to test run the motor. Once the direction of rotation is verified, the power supply shall be removed, and the drive reconnected, correctly aligned and covered with the appropriate guards.

7.9.8 When the above tests have been completed and properly documented, it shall be verified and documented that all safety device settings have been set to the values required by the specification(s) or by the manufacturer(s).

7.9.9 Records shall be kept of these tests. These tests shall be completed before the refrigerating system is charged with ammonia.

7.10 Pressure Testing

Pressure test shall be in accordance with Section 538 of ASME B31.5, latest edition, Refrigeration Piping and Heat Transfer Components and/or alternate methods with ASME B31.3-2010 Edition.

7.11 Leak Testing, Evacuation and Dehydration

Upon completion of installation, the ammonia refrigerating system shall have been field tested for tightness, evacuated, and if required dehydrated, in accordance with Appendix C. All parts of the system, including factory tested equipment, shall be exposed to field test pressures equal to those minimum design pressures listed in Appendix A or actual high and low side design pressures, whichever are greater. A pre-test inspection shall be made to verify that all components in the section of piping under examination have a pressure rating which meets or exceeds the specified field test pressure. All leaks shall have been repaired and defective material shall have been replaced.

7.12 Charging Procedure

7.12.1 At the completion of evacuation per C.5, break the vacuum with gaseous ammonia and introduce a sufficient amount to subject the system to approximately 100 psig (689.5 kPa gauge) (6.9 bar gauge) ammonia pressure.

7.12.2 The trained start-up technician shall fit pressure gauges to the system that are necessary for charging. All such instrumentation shall be calibrated and tested for accuracy.

7.12.3 For some refrigerating system installations, the ammonia is delivered in large cylinders. If practical, connect only one cylinder to the system at a time for charging.

7.12.4 If it is necessary to use a number of cylinders together, they shall be connected so as to prevent backfilling.

7.12.5 The system charging line is normally attached to an appropriate valve supplied by the installer. If no such valve is installed, the charging line shall be connected to an appropriate location where it will not cause liquid refrigerant to enter the compressor.

7.12.6 Insure all refrigerant charging hoses are suitable for ammonia, visually inspected for defects, and is within the service date stamped on the hose. If a hose is found to be damaged, not suitable for ammonia or beyond its service date, it shall not be used.

7.12.7 The cylinder from which the refrigerant is being charged into the system shall be located in open air whenever possible. In any case, the location of the refrigerant charging cylinder shall be in a position where it will not be a hazard to other personnel involved on the site. A notice shall be posted stating that the cylinder is being used for charging.

7.12.8 Ammonia refrigerant delivered by bulk delivery truck shall be pumped into the receiver or other vessel using the pump mounted on the truck. A flexible charging line suitable for transferring liquid ammonia refrigerant from the bulk delivery truck to the receiver shall be used. The charging line shall include a valve assembly consisting of, at a minimum, a check valve and an isolation valve. The transfer process shall be attended at all times.

7.12.9 During the delivery of ammonia by bulk delivery truck, the following considerations shall be made in addition to any required supplier unloading procedures: avoid positioning truck in front of any fresh air intake louvers–wind direction should be considered; secure storm drainage to prevent threat of contamination from an accidental release; non-essential personnel shall not be permitted within the established safety zone or shall wear PPE identical to those charging the system; site traffic shall be considered and routed to avoid collisions or damage to charging hoses; eye wash stations shall be located within 55 feet of the truck or portable eye wash stations shall be made available; any other site specific procedures that might exist.

7.12.10 During the refrigerant charging procedure, the operation of the refrigeration equipment and equipment connected to the refrigeration system in any way (including bulk transport vehicles) shall be monitored.

7.12.11 The total weight of refrigerant charged into the system shall be recorded.

7.13 Testing of Protection Devices

7.13.1 Compressor High Pressure Cut-out

The high pressure cut-out shall be tested and calibrated as required.

The compressor discharge pressure shall be increased slowly until the trained start-up technician can confirm that the cut-out operates at the required setting. If the high pressure exceeds the cut-out set point at which it is intended to operate, the compressor shall be manually stopped.

It is unacceptable to adjust the high pressure cutout set point for testing purposes.

If any cut-out fails to operate when tested, the fault(s) shall be traced and correct electrical and mechanical function confirmed before the refrigerating system is put into operation.

Cut-out pressure shall be set no greater than 90% of set pressure of any pressure-relief device that has a pressure common to the safety cut-out.

7.13.2 Compressor Low Pressure Cut-out

The low pressure cut-out, if supplied, shall be tested by gradually reducing suction pressure by progressively closing the compressor suction valve. It shall be confirmed that the cut-out operates at the required pressure.

If the suction pressure reaches the minimum recommended by the manufacturer and the cut-out has not operated, either the compressor shall be stopped or the suction pressure increased by gradually opening the partially closed valve.

Alternatively, the activation setting may be raised to a point above the compressor's operating suction pressure to verify that the cut-out operates.

7.13.3 Compressor Oil Differential Pressure Cut-out

Oil pressure cut-outs sometimes have an associated delay, giving necessary time for minimum oil pressure to be obtained on start-up; this should be taken into consideration during testing. There are two main types:

a. electrical bi-metal heater within the cut-out
b. separate electrical bypass by mechanical or electronic time delay.

The timer shall be tested by either:

- i) isolating the compressor main drive and simulating a start with the control circuitry,
- ii) isolating the oil pressure switch from the lubricating oil circuitry, if suitably valved,
- iii) adjusting or throttling the lubrication system oil pressure to a pressure below the oil switch setting,
- iv) or the integrated test function, if supplied.

7.13.4 Compressor High Temperature Cut-outs

High temperature cut-outs such as discharge vapor or oil temperature cut-outs shall be tested by increasing the temperature of the device to the cutout set point.

7.13.5 Compressor Refrigerant Level Protection Devices

All other compressor shutdown and alarm devices, such as liquid level controls, shall be tested for operation and setting to the system designer or manufacturer's recommendations. These refrigerant level devices may include, but are not limited to:

a. High level cut-outs
b. High level alarms
c. Low level alarms
d. Low level cut-outs.

7.13.6 Other Compressor Protection Devices

All other compressor shutdown and alarm devices, such as low temperature cut-outs, shall be tested for operation and setting using the manufacturer's recommendations.

7.14 System Monitoring

When the above tests have been completed satisfactorily, the start-up may proceed with the adjustment of regulating and control valves to achieve correct function. Throughout the whole start-up procedure, there shall be frequent monitoring of pressures and temperatures in the system and vigilance for ammonia leaks. Should any abnormal situation occur the affected equipment shall be addressed and/or stopped immediately. The source of the abnormality shall be located and corrected before the affected equipment is re-started.

7.15 Commissioning

7.15.1 Commissioning does not necessarily require full performance operation. At commissioning, the system shall be operated with the available heat load.

7.15.2 During the commissioning of the system the trained start-up technician shall involve the persons responsible for the day-to-day operation of the system.

7.15.3 The system shall be operated to demonstrate correct function. During the commissioning, pressures and temperatures shall be recorded and all level controls shall be checked for satisfactory operation.

7.15.4 Following the training of the system operators, and after safety and function have been demonstrated, and there has been a period of continuous and fault free running, the refrigeration system may be handed over to the persons responsible for the day-to-day operation of the system.

7.15.5 The manufacturer's instructions on oil and filter changes during start-up and the first weeks of operation shall be observed.

7.15.6 The operating staff shall log pressures, temperatures and levels, and inspect the system for leaks, oil consumption and other faults, if any, at frequent intervals. This procedure shall not be confined to the machinery room but should also include the entire refrigerating system.

7.15.7 The Commission shall be considered complete when the requirements of items 7.15.1, 7.15.2, 7.15.3, 7.15.4, 7.15.5 and 7.15.6 are satisfied.

Section 8

Start-Up of Additions and Modifications to Existing Installations

8.1 General

A typical procedure to be followed during start-up is given below for guidance, but it is emphasized that the procedure will need to be tailored to suit the scope of additions or modifications to the individual refrigerating system.

8.2 Pre-Start-up Safety Review

See Section 7.3 Pre-Start-up Safety Review

8.3 Delivery of Information

See Section 7.7 Delivery of Information

8.4 Initial Status and Safety Provisions

8.4.1 The trained start-up technician shall review the installation of the refrigerating system and associated equipment with those responsible for its installation. A procedure for communication between those responsible for the installation and the trained start-up technician shall be established.

8.4.2 Prior to commencement of start-up, a visual inspection shall include, but not be limited to, all piping, electrical wiring, supports covers, and guards to insure the system is in proper order.

8.5 Electrical Equipment

8.5.1 Before a system is started up, it shall be visually inspected by the owner or the owner's designated representative. The owner or the owner's designated representative shall verify electrical wiring is correct and properly supported, the control panel(s) have been inspected both internally and externally, and that all specified equipment has been correctly installed and that all fuses or circuit breakers installed in the panel(s) are of the correct rating, as indicated in the specification.

8.5.2 When the appropriate tests have been completed and properly documented, it shall be verified and documented that all safety device settings have been set to the values required by the specification(s) or by the manufacturer(s).

8.5.3 Records shall be kept of these tests. These tests shall be completed before the additions or modifications to the refrigerating system are charged with ammonia.

8.6 Pressure Testing

Pressure test shall be in accordance with Section 538 of ASME B31.5, latest edition, Refrigeration Piping and Heat Transfer Components and/or alternate methods with ASME B31.3, latest edition.

8.7 Leak Testing, Evacuation and Dehydration

Upon completion of the installation, the ammonia refrigerating system shall be field tested for tightness in accordance with Appendix C. A pre-test inspection shall be made to verify that all components in the portion of the ammonia refrigerating system under examination have a pressure rating which meets or exceeds the specified field test pressure. All leaks shall have been repaired and defective material shall have been replaced.

8.8 Testing of Protection Devices

See Section 7.13 Testing of Protection Devices for use where applicable.

8.9 System Monitoring

When the above tests have been completed satisfactorily, the start-up may proceed with the adjustment of regulating and control valves to achieve correct function. Throughout the whole start-up procedure, there shall be frequent monitoring of pressures and temperatures in the system and vigilance for ammonia leaks. Should any abnormal situation occur, the refrigeration system shall be stopped immediately. The source of the abnormality shall be located and corrected before the system is re-started.

8.10 Commissioning

8.10.1 Commissioning of added or modified areas of the refrigeration system does not necessarily require full performance operation. At commissioning, the system shall be operated with the available heat load.

8.10.2 During the commissioning of the added or modified areas of the refrigeration system the trained start-up technician shall involve the persons responsible for the day-to-day operation of the system.

8.10.3 The added or modified areas of the refrigeration system shall be operated to demonstrate correct function. During the commissioning, pressures and temperatures shall be recorded and all level controls shall be checked for satisfactory operation.

8.10.4 Following the training of the system operators on those added or modified areas of the refrigeration system, and after safety and function of those added or modified areas of the refrigeration system have been demonstrated, and there has been a period of continuous and fault free running of those added or modified areas of the refrigeration system, the refrigeration system may be handed over to the persons responsible for the day-to-day operation of the system.

8.10.5 The manufacturer's instructions on oil and filter changes during start-up and the first weeks of operation shall be observed if applicable.

8.10.6 The operating staff shall log pressures, temperatures and levels, and inspect the system for leaks, oil consumption and other faults, if any, at frequent intervals. This procedure shall not be confined to the machinery room but should also include the entire refrigerating system.

8.10.7 The Commission of the added or modified areas of the refrigeration system shall be considered complete when the requirements of items 8.10.1, 8.10.2, 8.10.3, 8.10.4, 8.10.5 and 8.10.6 are satisfied.

Section 9

Sources of References (Informative)

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

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

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

International Institute of Ammonia Refrigeration (IIAR)
1001 North Fairfax Street, Suite 503
Alexandria, VA 22314, USA
www.iiar.org

National Institute for Occupational Safety and Health (NIOSH)
1600 Clifton Rd.
Atlanta, GA 30333
www.cdc.gov/niosh

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

Superintendent of Documents
United States Government Printing Office (GPO)
Washington, DC 20401, USA
www.gpo.gov

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

Appendix A (Normative)

Pressures

The minimum ammonia design pressures stipulated for the various types of equipment specified in the Equipment section of ANSI/IIAR 2. (ref. 4.3.1) and ASME B31.5 (ref. 4.1.2) are duplicated below for convenient reference. Note that the maximum working pressure of particular systems may require higher design pressures and the strength and leak test pressure will be accordingly higher.

Equipment	**Minimum Design Pressure**	
	psig	**(bar gauge)**
Compressors:		
High-stage with water-cooled or evaporative condensing	250	(17.2)
High-stage with air-cooled condensing [Note 1]	300	(20.7)
Booster	150	(10.3)
Air-cooled condensers and air-cooled desuperheaters	300	(20.7)
Evaporative condensers	250	(17.2)
Shell-and-tube condensers and double-pipe condensers	250	(17.2)
Plate heat exchanger condensers	250	(17.2)
Forced air evaporator coils [Note 2] [Note 7]	150	(10.3)
Shell-and-tube evaporators (refrigerant in shell)[Note 2][Note 7]	150	(10.3)
Shell-and-tube evaporators (refrigerant in tubes) [Note 2] [Note 7]	150	(10.3)
Plate heat exchanger evaporators [Note 2] [Note 7]	150	(10.3)
Pressure Vessels:		
Highside service utilizing water-cooled or evaporative condensing	250	(17.2)
Highside service utilizing air-cooled condensing	300	(20.7)
Lowside service [Note 3]	150	(10.3)
Refrigerant pumps – refrigerant pressure containment envelope:		
Highside service utilizing water-cooled or evaporative condensing	250	(17.2)
Highside service utilizing air-cooled condensing	300	(20.7)
Lowside service [Note 4]	150	(10.3)
Refrigerant valves at fluid and ambient temperatures of -20 °F (-29 °C) to 240 °F (116 °C) [Note 5]	300	(20.7)
Controls [Note 6]	300	(20.7)

Notes:

1 **Exception:** Minimum lowside design pressure for reciprocating compressors shall be 250 psig (1720 kPa gauge) (17.2 bar gauge)

2 **Exception:** Minimum ammonia-side design pressure shall be the greater of:

a) 250 psig (1720 kPa gauge) (17.2 bar gauge) where hot gas defrost is utilized or hot gas pressure may be applied to the evaporator.

b) The high side hot gas source design pressure where hot gas defrosts is utilized or hot gas pressure may be applied to the evaporator.

c) The design saturated temperature of the evaporation process.

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

4 **Exception:** Application design pressure which exceeds these minima shall prevail.

5 **Exception:** ANSI-class flange-mounted valves (7.1) are permitted within the ANSI design pressure-temperature envelope. For temperature below -20 °F (-29 °C), see paragraph 523 of ASME B31.5, latest edition, Refrigeration Piping and Heat Transfer Components (ref. 4.1.2).

6 **Exception:** For controls designed specifically for and usable for lowside use exclusively, minimum design pressure shall be 150 psig (1050 kPa gauge) (10.3 bar gauge)

7 Other types and styles of evaporators may be utilized within a Closed-Circuit Ammonia Mechanical Refrigeration System. When types and styles of evaporators which are not listed are utilized, consult with the equipment manufacturer to determine the Minimum Design Pressure rating.

The above pressure data shall not be used in lieu of the stipulated minimum design pressures for the various types of equipment specified in the Equipment section in the governing edition of ANSI/IIAR 2 (ref. 4.1.3).

Appendix B (Normative)

Machinery Rooms and Auxiliary Safety Equipment

B.1 General

Inspection at start-up and commissioning shall certify that the machinery room complies with local governing Codes, the requirements of ASHRAE 15, latest edition (ref. 4.1.1) and with the requirements of IIAR 2-latest edition (ref.4.1.3).

B.2 Protective Equipment

The following language applies to systems that exist in the United States. In other nations, requirements may differ. It is the responsibility of all stakeholders to insure all legal and jurisdictional requirements have been met:

Protective clothing, goggles, respirators and gloves, carefully and safely stored, shall be readily available in the vicinity of the system but outside the area of risk. PPE and its use shall conform to OSHA regulations: 29 CFR 1910.132, General Requirements (ref. 4.1.4.2), 29 CFR 133, Eye and Face Protection (ref. 4.1.4.3), 29 CFR 1910.134, Respirators (ref. 4.1.4.4) and Gloves CFR 29 1910.138.

Respirators or SCBAs (Self Contained Breathing Apparatus), full protective clothing, and lifeline (suitable for its intended purpose) should be available outside area of risk for use by trained personnel where rescue work or emergency isolation of equipment may have to be undertaken.

Fire fighting equipment appropriate to the system and to ammonia *may* be provided. Adequate first aid equipment shall be provided in the same safe area as protective equipment and self-contained breathing sets.

Concise and precise first aid instructions shall be clearly displayed in the machinery rooms and their accesses. Any regular first aid personnel shall be made fully aware of the human physiological consequences of exposure to ammonia.

The location of personal protective, first aid and rescue equipment shall be clearly indicated on notices within and outside the areas of risk.

Emergency eyewash / safety showers shall be installed at machinery rooms per IIAR 2. Portable irrigation facilities and/or eye wash bottles containing an eye wash solution or distilled water shall be available.

B.3 Electrical

Lighting shall be of adequate brightness (per ANSI/IESNA RP-7-01) and disposition to allow safe, unencumbered movement of personnel. An emergency lighting system installed in accordance with 29 CFR 1919.37(b) shall be provided to allow evacuation of personnel and any necessary urgent operation of controls, or portable lighting shall be provided.

Independent or standby supplies of electricity (example: batteries) for emergency and warning systems shall be tested. Visual and audible alarms shall be available and verified to be operating properly per B.3.1 below. The meaning and function of each switch and alarm shall be clearly identified in accordance with codes and standards. Ammonia/air mixtures can deflagrate but only at the concentration of 16% to 25% by volume if ignited by a high temperature source. A low concentration of 100 ppm is readily detected by smell and by suitable detectors. Accordingly, the following precautions shall be taken:

B.3.1 In machinery rooms, equipment de-energization shall be initiated by one or both of the following in accordance with IIAR 2 and other codes and standards applied by the authority having jurisdiction.

i) In machinery rooms that are not continually monitored by trained on-site personnel: provide one or more refrigerant detectors operative at a pre-determined level or concentration. The detector(s) or sampling tubes that draw air into the detectors shall be located in an area where refrigerant from a leak is likely to concentrate and shall initiate automatic equipment de-energization. Detector(s) shall also initiate visual and audible alarms inside and outside of the area. These detectors may initiate ventilation in accordance with B.4 below. In addition a manually operated switch as described in B.3.1 ii) shall be provided.

ii) In machinery rooms that are continually monitored by trained on-site personnel: provide a manually operated tamper proof switch immediately outside of the principle entrance. Switch(es) shall initiate visual and audible alarms inside and outside of the area as well as initiate automatic equipment de-energization.

B.4 Ventilation

Mechanical ventilation equipment shall be installed in accordance with local governing Codes, ASHRAE 15 (latest edition) and ANSI/IIAR 2 (latest edition). Ventilation equipment shall be installed and be capable of exhausting from the room at least the amount of air as required by the applicable standard. Inlets to the ventilation system shall be free from obstruction, near the machinery and suitably guarded. Discharge to the outside of the building shall be free from obstruction and shall not cause an unreasonable hazard. Provision shall be made for adequate replacement fresh air to be introduced throughout the room.

The ventilation system shall be automatically activated by refrigerant detectors. The ventilation system shall also be capable of manual activation through an independent emergency control switch outside and near the principle machinery room door (with another at ground level if the machinery room is not at ground level). This switch is separate from the equipment shut-down switch described in B.3.1.

In addition to the manually operated switch described above, an additional manual on/off/auto tamper proof switch shall be located remotely (as agreed upon with local authorities having jurisdiction) for use by emergency responders who may wish to start or stop the ventilation system depending on circumstances.

B.5 Guards

Guards shall be adequate to prevent access to and injury from all rotating equipment, injury from electrical items and dangerously hot or cold surfaces. Further information can be obtained from OSHA 29 CFR 1910.212 and 29 CFR 1910.219.

B.6 Refrigerant Storage

Refrigerant stored in the machinery room, apart from the charge in the system, shall be stored only in approved storage cylinders or vessels.

Appendix C (Normative)

Leak Test, Evacuation and Dehydration

C.1 General – Start-up of New Installations

Upon completion of installation, the ammonia refrigerating system shall be field tested to insure that it is leak free. All parts of the system not factory tested shall be exposed to field test pressures equal to those minimum design pressures listed in Appendix A or actual high and low side design pressures, whichever are greater. A pre-test inspection shall be made to verify that all components in the section of piping under examination have a pressure rating which meets or exceeds the specified field test pressure. All leaks shall have been repaired and defective material shall have been replaced.

C.2 Leak Testing

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

C.2.1 Preparation for Leak Testing

All joints shall remain un-insulated until field leak testing has been completed. Note that some jurisdictions require welded joints to remain unpainted until field leak testing has been completed and witnessed by a representative of the jurisdiction.

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

C.2.2 Pressurization Procedure

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

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

C.2.3 Initial Leak Testing

The high side and low side of the system shall be leak tested at the greater of:
a. The relevant design pressure shown in Appendix A, or
b. The design pressure for which that part of the system has been designed. The system shall be held under pressure until proven tight with no more than a 1% loss in pressure, after accounting for temperature effects. For tie-ins to existing systems see Appendix F.

A suitable dry gas such as nitrogen or air shall be used for field leak testing to gradually raise the pressure in the ammonia system to that required for this test with the following provisions:
a. There shall be a suitable regulator located between the pressure source and the refrigeration system to control the supply pressure.

b. There shall be a suitable relief device located on the refrigeration system side of the regulator rated for the full discharge capacity of the air compressor when an air compressor is used as the pressure source.

c. There shall be a suitable relief device located on the refrigeration system side of the regulator rated for the full discharge capacity of the regulator when a nitrogen cylinder or tank is used as the pressure source.

All leaks shall be repaired, all defective material shall be replaced and the test procedure repeated until the system is proven tight.

Upon completion of the initial leak test, all preparations undertaken in Section C.2.1 shall be reversed.

C.3 Evacuation

Upon completion of the leak test, evacuate the system to a vacuum of at least 16" Hg (about 406,000 microns) and hold for charging.

C.4 Dehydration

When water removal is required, follow the steps below.

After the piping has been leak tested and proven tight the entire system shall be evacuated with a vacuum pump to remove air and moisture.

Pressure switches should be valved off or disconnected since some switches may not have vacuum protection. All manual valves except those open to atmosphere must be opened and all control valves, such as solenoid valves, should be jacked open or electrically energized (if normally closed). Air or motor operated valves must also be open.

All seal volumes and other components requiring an oil charge for sealing should be charged with the specified oil and any rotating devices should be turned over by hand to assure distribution of this seal oil, etc. to the seal faces. Refer to the manufacturer's recommendations for any special considerations to be followed during pressure testing and/or evacuation.

All reasonable measures should be taken to drain or blow out any free standing water in the system.

Connect a suitably sized vacuum pump to appropriately located valves. Start the pump and evacuate until a pressure of 10,000 microns is attained. Evacuation to this point should be rather rapid but if free water is present the process will be slowed as evaporation of the water takes place. Check low points, traps, etc. for cold spots indicating the presence of water and apply heat as needed to speed up the evaporation of water.

Continue evacuation to 5000 microns.

When a pressure of 5000 microns has been reached, shut off the vacuum pump and allow the system to stand for 1 hour. Allow no more than 1000 microns rise in pressure over the 1 hour period, assuming a relatively constant ambient temperature. A Pressure Chart is found in Appendix H.

C.5 Termination of Evacuation

At the completion of evacuation, break the vacuum with gaseous ammonia and introduce a sufficient amount to subject the system to approximately 100 psig (689.5 kPa gauge) (6.9 bar gauge) ammonia pressure. At the completion of evacuation and final leak check, return all automatic and electrically controlled valves to their normal operating positions. Any other controls or valves which were manually opened for the evacuation procedure shall also be returned to their normal operating state.

Appendix D (Informative)

Pre-Charging and Pre-Start-Up Check Lists

The Pre-Charging and Pre-Start-up Check Lists shown below cover the equipment and component checks required for a typical Component Group.

Examples of system Component Groups include:

Compressor package(s)
Condenser(s)
High Pressure vessel(s)
Intermediate and Low Pressure vessel(s)
Piping Mains
Piping Branches
Evaporator(s)
Non-condensable gas purgers

Typical Pre-charging Check List Items

Ammonia Safety Training Complete
Hazard Review Complete
Ventilation System Operational
Alarms Operational
Adequate Water Supply Available
Eyewash Station Operational
Ammonia Detection System Operational
Emergency Shutdown Operational
Evacuation and Pressure Testing Complete
Appropriate State and Federal Registration Forms Submitted

Typical Pre-Start-up Check List

Condenser Passivation Completed
High Level Cut-Outs Operational
Condenser Operational
Ammonia Inventory Recorded
Water Treatment System Operational
Note all temporary conditions or settings

(Example of) Screw Compressor Pre-Start-up Checklist		
Date:		
Customer:	Location:	Technician:
Unit Number		
Manufacturer		
Model Number		
Serial Number		
Compressor Duty HS/LS/Swing		
Type of Refrigerant		
Motor Manufacturer		
HP/Voltage/RPM		
Oil level		
Unusual noise or vibration		
Refrigerant leaks		
Oil leaks		
Control settings checked		
Safety settings checked		
Oil temperature		
Suction/Discharge Pressure		
Check motor/compressor alignment		
Thrust clearance on compressor		
Record vibration		
Oil analysis complete		
Change oil filters		
INSPECTION REMARKS:		

(Example of) Reciprocating Compressor Pre-Start-up Checklist		
Date:		
Customer:	Location:	Technician:
Unit Number		
Manufacturer		
Model Number		
Serial Number		
Compressor Duty HS/LS		
Motor Manufacturer		
HP/Voltage/RPM		
Oil level		
Unusual noise or vibration		
Refrigerant leaks		
Oil leaks		
Do safety switches function		
Suction/Discharge Pressures		
Oil temperature		
Belt tension/Coupling alignment		
Check compressor/motor alignment		
Check motor starter contacts		
Perform top end inspection		
Replace oil filters		
Replace oil		
Inspect rod clearances		
INSPECTION REMARKS:		

(Example of) Evaporative Condenser Pre-Start-up Checklist		
Date:		
Customer:	Location:	Technician:
Unit Number		
Manufacturer		
Model Number		
Serial Number		
Number of Fans		
Motor Manufacturer		
HP/Voltage		
Water Pump Model Number		
Are fans operating		
Any unusual noise or vibration		
Water nozzles working properly		
Sump water level correct		
Does the sump need to be cleaned		
Do the coils need to be cleaned		
Are there any water or refrigerant leaks		
Bearings lubricated		
Mist eliminators in place		
Water treatment operating properly		
White Rust visible		
Belt alignment		
Belt condition		
Head pressure control settings		
INSPECTION REMARKS:		

(Example of) Recirculator Pre-Start-up Checklist		
Date:		
Customer:	Location:	Technician:
Unit Number		
Manufacturer		
National Board Number		
Diameter		
Length		
Pump Manufacturer		
Model Number		
Pump suction/discharge pressure		
Is float column free of oil		
Is reservoir filled with oil		
Seal leaks		
Does reservoir switch work		
Check level controls		
Drain Oil Pots		
Is insulation satisfactory		
Drain any oil from pumps		
Check level controls		
Check pump controls		
INSPECTION REMARKS:		

(Example of) Evaporator Pre-Start-up Checklist		
Date:		
Customer:	Location:	
Unit Number		
Manufacturer		
Model Number		
Number of Fans		
HP/Voltage		
Defrost		
Room temperature		
Are all fans running		
Ice present		
Unusual noise or vibration		
Do the coils need to be cleaned*		
Refrigerant leaks**		
Superheat setting		
Defrost schedule		
Check coils for refrigerant leaks		
Is drain pan clean and draining		
Fan belts condition		
Electrical connections tight		
Fan guards secure		
Is drain heat trace working		
INSPECTION REMARKS:		
* Spot check coils for cleanliness so that they can be cleaned during the annual inspection or as required. ** Sample air in the room for refrigerant leaks. If a leak is detected, locate the source and repair it.		

Appendix E (Informative)

Purging

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

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

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

The use of automatic purgers is highly recommended. Manual purging can be wasteful, inefficient and hazardous. Manual purging is most effective when the system is in operation and non-condensable gases are concentrated and trapped at the condenser outlets. However, manual purging while in operation at the condenser outlets carries the risk of releasing liquid ammonia. Manual purging while not in operation is safer but less effective. Refer to the condenser manufacturer's published recommendations for purge locations and procedures.

Appendix F (Informative)

Considerations and Planning for Closed-Circuit Ammonia Refrigerating System Tie-Ins

F.1 General

Tie-ins represent a special case in Commissioning and Start-up of Closed-Circuit Ammonia Refrigerating Systems. For purposes of this section, tie-ins are defined as the connection point between an existing Closed-Circuit Ammonia Refrigerating System and a new sub-system. The sub-system can be simple to extensive, adding one minor component or a complex network of piping and components. In either case, the tie-in to an existing system presents challenges with regard to conformance with the pressure testing and evacuation portions of this Standard. The purpose of this Informative section is to provide guidance as to how to safely and effectively make a tie-in given the time constraints that operating refrigeration systems impose.

Under no circumstances is the sub-system itself – the piping, equipment and valves leading up to the tie-in– exempt from the requirements of this document. The sub-system should be completely pressure tested prior to making the tie-in. This section refers only to the weld or welds immediately adjacent to the point of tie-in.

Develop a Tie-in Procedure that includes/addresses the following:

a) A Pump-Out and Line/Equipment Opening Procedure (refer to IIAR 7 – Section 8.4).

b) A Leak Test, Evacuation, and Dehydration Procedure (refer to Appendix C).

c) A Change Management Procedure (that includes training) of the entire tie-in installation/project [refer to your company's procedure and/or the Process Safety Management (PSM) Management of Change (MOC) element if subject to OSHA and EPA regulations for compliance].

d) Modifications to the Commissioning and Start-up Procedure for the specific tie-in (refer to Section 8).

Where no or few provisions have been made to facilitate tie-ins, and as these refrigeration systems are in service, the time required to make a tie-in can impact the operation the refrigeration system it is serving. The tie-ins can impact production schedules, temperature levels, etc. All tie-in periods must then recognize their total impact. While adhering to all jurisdictional regulations and safety requirements, a practical component to tie-ins must be acknowledged.

Due to these practical concerns, the procedures listed here, while unquestionably the best practice, may need to be modified to accept the realities of the existing situation. These modifications could include eliminating a deep evacuation of a sub-system after a pressure test or accepting the introduction of moisture into a refrigeration system. It may not be possible to keep the entire sub-system in a vacuum, if an evacuation is required, when tying in to an existing system. A portion of the piping must remain open to atmosphere while certain welds are being made. If the owner or the owners' representative requires an evacuation of the system or sub-system, there must be an allowance for the downtime required to execute the evacuation. Individual systems will have unique requirements.

Modifications to the Commissioning and Start-up procedure outlined in these documents for tie-ins should be discussed with all the interested parties in the planning phase of the tie-ins.

Agreement on which aspects of Commissioning and Start-up will be adhered to and which tenets will be omitted should be thoroughly discussed.

F.2 Planning for Future Expansion

F.2.1 Determine locations and size for extra valves that could facilitate future expansion. Consider what portions of the system or equipment might have to be isolated or shut down to make a tie-in if an extra valve is not installed during original construction.

F.2.2 Determine locations for purge/pump-out connections. For those portions of the system or equipment that will have primary isolation valves, install purge valves to assist in the pump out of that section of piping or equipment.

F.2.3 When dead-end valves are installed, the size of the valve should be large enough to handle expected future capacity at an acceptable pressure loss. Consider the direction of flow and valve orientation when installing valves. If possible, the source of pressure or flow should be from beneath the valve seat. The dead-end valves in the main line should not be closed. Main line dead-end valves should be blank-flanged or installed with a capped short pipe stub of an appropriate rating for the portion of the system to which it is installed. Attach a service valve to the stub or to the blank flange. Fit a gauge or plug to the outlet of the service valve. See Notes below:

Note:
1. If a pipe stub is connected to the valve it should be approximately 12” long. The added length of the stub, plus the use of a heat sink (like a wet rag) will reduce the possibility of damage to the valve seat when a future connection is made to the pipe stub.
2. Ensure that safe operating procedures (including lockout/tagout) are established and adhered to for dead-end valves.

F.2.4 Analyze possible future facility load additions that could reasonably be expected to occur. Consider providing future tie-in valves at the following locations:
a. End of main headers.
b. Connection off of main headers for future compressors, condensers, vessels, other equipment.
c. Future processing equipment.
d. Future mechanical refrigerant pumps, or liquid transfer units.

Consider locating valves in the system so that they could be closed to facilitate future expansion.

Consider installing additional valves that could reduce the possibility of an extended or difficult shutdown.

Consider locating valves to avoid the trapping of liquid during future expansion.

F.2.5 During the installation verify that all refrigerant lines and valves are properly identified.

F.2.6 Make tie-in locations so that refrigerant flow in the proper direction will be aided by gravity. An alternative is to design for added pressure losses where return lines are trapped.

F.3 Planning Individual Load Additions

F.3.1 Verify line and valve sizes. Check the capacity of additional loads against the capacity of the existing line(s). Determine that the pressure loss in the lines is in accordance with acceptable standards and practices.

F.3.2 Develop written operating procedures for the system addition. Add revisions as necessary to the Emergency Response and Planning program. Incorporate into the facility training program the operation and maintenance of new equipment and system additions. Amend process flow, P&ID, electrical, and architectural drawings to reflect changes to be made.

F.3.3 Determine the location for tie-in, and the size of isolation valve(s) to be added. When connecting into an existing system consider installing a shut-off valve at the tie-in point. Consider installing tie-in valve(s) first, so planned system modifications can proceed without interrupting the system operation.

F.3.4 Coordinate the tie-in with plant operations. Consider the shutdown time necessary to make the required tie-in and the effect on facility production or storage temperatures.

F.3.5 Develop written procedures that will be used for testing the newly installed piping and equipment.

F.3.6 For all modifications follow change management procedures. Ensure that the jurisdictional authority when required reviews all designs and installations. Note: Facilities covered by the OSHA Process Safety Management regulation should use the Management of Change procedures established for that program.

Appendix G (Informative)

Temperature Reduction Procedure for Newly Constructed Cold Storage Areas

For any new rooms, lower the room temperature according to the following recommendations, or follow guidelines of room material supplier(s):

LEAVE DOORS AJAR to prevent negative pressure damage to the facility during the Phase I and Phase III pull downs. Close doors during Phase II to prevent moisture intrusion into the cold space.

Phase I – Pull down from Ambient to 35 °F.

Lower temperatures with the following time schedule:

Time	Maximum Room Reduction	Minimum Room Temperature
24 Hours	10 °F	75 °F
24 Hours	15 °F	60 °F
24 Hours	15 °F	45 °F
24 Hours	5 °F	40 °F
24 Hours	5 °F	35 °F

Phase II–Hold at 35 °F for concrete cure

35 °F shall be maintained in rooms that will operate below freezing until the concrete contractor or engineer verifies that the concrete has cured and it is safe to proceed with Phase III. In lieu of concrete curing verification, the following can be used to indicate that the concrete has cured:

- Verification that doors have remained closed and other sources of moisture have not been present, and
- Room humidity has stabilized, and
- The evaporator unit(s) have cycled through at least two (2) defrost cycles and the evaporator coils have remained dry and reasonably free of frost for at least 24 hours.

Phase III – Pull down from 35 °F to room operating temperature.

Lower temperatures with the following time schedule:

Time	Maximum Room Reduction	Minimum Room Temperature
24 Hours	5 °F	30 °F
24 Hours	10 °F	20 °F
24 Hours	10 °F	10 °F
24 Hours	10 °F	0 °F
24 Hours	10 °F	-10 °F
24 Hours	10 °F	-20 °F

Appendix H (Informative)

Pressure Chart

Atmospheric Pressures Absolute Values			Compound Gage Reading	Saturation Point of Water
Microns	**psia**	**in. Hg**	**in. Hg Vacuum**	**°F**
759,999	14.7	29.92	0.00	212.00
724,007	14.0	28.50	1.42	209.56
672,292	13.0	26.47	3.45	205.88
620,577	12.0	24.43	5.94	201.96
568,862	11.0	22.40	7.53	197.75
517,147	10.0	20.36	9.62	193.21
465,432	9.0	18.32	11.60	188.28
413,718	8.0	16.29	13.63	182.86
362,003	7.0	14.25	15.67	176.85
310,289	6.0	12.22	17.71	170.06
258,573	5.0	10.18	19.74	162.24
206,859	4.0	8.14	21.78	152.97
155,144	3.0	6.11	23.81	141.48
103,430	2.0	4.07	25.85	126.08
51,715	1.0	2.04	27.89	101.74
46,543	0.90	1.83	28.09	98.24
41,371	0.80	1.63	28.29	94.38
36,200	0.70	1.43	28.50	90.08
31,029	0.60	1.22	28.70	85.21
25,857	0.50	1.18	28.90	79.58
20,686	0.40	0.81	29.11	72.86
15,514	0.30	0.61	29.31	64.47
10,343	0.20	0.41	29.51	53.14
5,171	0.10	0.20	29.72	35.00
0	0.00	0.00	29.92	—

Notes:
psia x 2.035966 = in. Hg
psia x 51,715 = Microns

International Institute of
Ammonia Refrigeration

1001 N. Fairfax Street
Suite 503
Alexandria, VA 22314
(703) 312-4200
Fax: (703) 312-0065
www.iiar.org