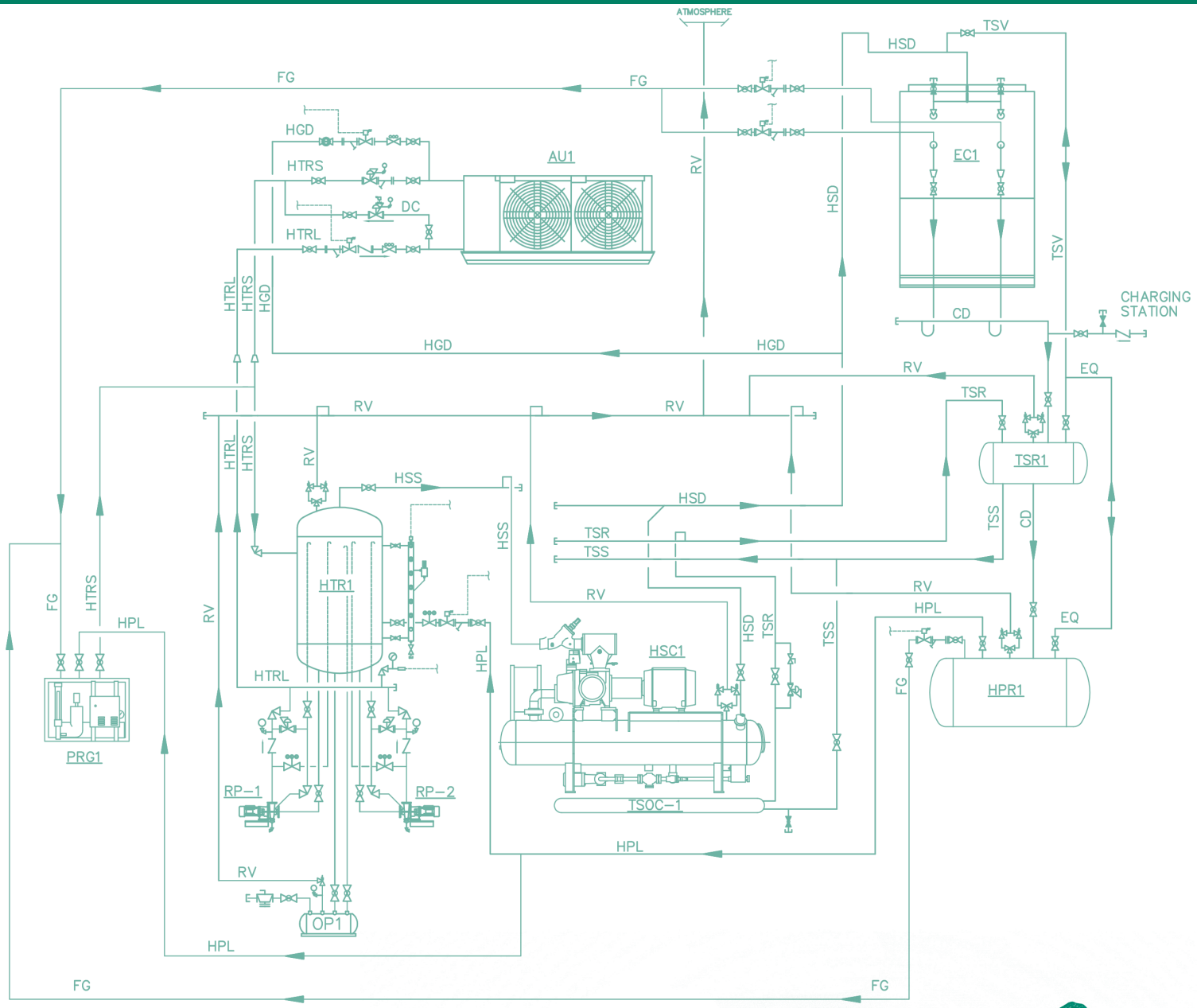
American National Standard for

ANSI/IIAR 7-2013

Developing Operating Procedures for Closed-Circuit Ammonia Mechanical Refrigerating Systems



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International Institute of Ammonia Refrigeration

IIAR 7

Developing Operating Procedures for Closed-Circuit Ammonia Mechanical Refrigerating Systems

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Notes on the Standard Text

Metric Policy

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FOREWORD (Informative)

The purpose of this standard is to define the minimum requirements for developing operating procedures for closed-circuit ammonia mechanical refrigerating systems. The document reflects the consensus reached by ammonia refrigeration industry representatives on how to develop operating procedures.

Since this document defines the minimum requirements for operating procedures it may not be sufficient to meet other standards and/or regulations that are applicable to each specific refrigerating system. Additional requirements may be necessary to comply with these standards and/or regulations. The International Institute of Ammonia Refrigeration's (IIAR's) *Process Safety Management Guidelines for Ammonia Refrigeration* and the IIAR's *Risk Management Program Guidelines for Ammonia Refrigeration* address the additional requirements needed to meet United States regulations. Note that this standard does not constitute a comprehensive detailed technical design manual and should not be used as such.

This is a new Standard intended to replace the operations information contained in IIAR Bulletin #110, *Guidelines for Start-Up, Inspection, and Maintenance of Ammonia Mechanical Refrigerating Systems,* and to supplement existing refrigeration standards and publications issued by other organizations such as ASHRAE, ASME and ANSI.

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

Robert J. Czarnecki, Chair — Campbell Soup Company
Don Faust, Vice Chair — Gartner Refrigeration & Mfg., Inc.
Eric Brown — ALTA Refrigeration, Inc.
Dennis R. Carroll — Johnson Controls
Trevor Hegg — EVAPCO, Inc.
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Ron Worley — Nestlé USA
Dave Schaefer — Bassett Mechanical
Joseph Pillis – Johnson Controls
Peter Jordan – MBD Risk Management Services, Inc.

The task group working on this standard had the following members at the time of publication:

Robert Czarnecki — Campbell Soup Company
Peter Jordan — MBD Risk Management Services, Inc.
James Marrella — United States Cold Storage, Inc.
Godan Nambudiripad — Retired, General Mills
John Landis — Pepperidge Farm, Inc.
Jack Piho — Piho Engineering

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SECTION 1

PURPOSE

1.1 The purpose of this standard is to define the minimum requirements for developing operating procedures for closed-circuit ammonia mechanical refrigerating systems. These operating procedures shall be developed with the following primary goals in mind:

a. Easy to Understand and Follow
b. Safe
c. Effective
d. Reliable
e. Meeting Applicable Regulatory Requirements

SECTION 2

SCOPE

2.1 This document presupposes that the persons who use it have a working knowledge of the functionality of their ammonia refrigerating system(s) and basic ammonia refrigerating practices and principles. This standard is intended for those who develop, define, and/or review operating procedures for ammonia refrigerating systems.

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

2.3 This document does not address the commissioning of ammonia refrigerating systems or system components. Refer to IIAR5 *Start-up and Commissioning of Closed-Circuit Ammonia Mechanical Refrigerating Systems for the criteria and procedures to start-up and commission systems or system components.*

SECTION 3

DEFINITIONS

For other definitions refer to IIAR 2 *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating* Systems or IIAR 1 *Definitions and* Terminology whichever is the later document.

Emergency operating procedures: Procedures for operating the system under abnormal, unintended, or time sensitive conditions. These abnormal or time-sensitive conditions may involve risk to the health and welfare of operators, employees, and the public; and/or components of the refrigerating system; and/or product.

Emergency shutdown procedures: Procedures which describe the deliberate and immediate shutdown of the system or a component in the system due to an unplanned critical circumstance.

Initial start-up procedures: Procedures which describe the steps needed to verify the condition of the equipment and the steps to start the system or a component in the system safely under normal conditions.

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Normal operations procedures: Procedures which describe the steps needed to verify the condition of the equipment and the steps to start and run the system or a component in the system safely under normal conditions.

Normal shutdown procedures: Procedures which describe the steps needed to stop the system or a component in the system safely under normal conditions.

Start-up procedures following a turnaround, or after an emergency shutdown: Procedures which describe the steps needed to verify the condition of the equipment and the steps to start the system or a component of the system safely following abnormal shutdown conditions or a turnaround such as power failures or emergency shutdowns. Start-up following an emergency or major change may require more inspections to verify that valves are in their appropriate positions and all equipment is functioning properly.

Temporary operating procedures: Procedures which describe the deliberate and planned operation of a piece of equipment at conditions outside of its normal operating conditions, but within its upper and lower safe operating limits, including any specific steps that must be taken so that there are no safety ramifications. Typically, temporary operating procedures are of a limited duration.

SECTION 4

REFERENCES

4.1 Normative References

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

4.1.1.1 Code of Federal Regulations, 29CFR 1910.119, *Process Safety Management of Highly Hazardous Materials* (PSM Standard).

4.1.1.2 Code of Federal Regulations, 29CFR 1910.120(q), *Hazardous Waste Operations and Emergency Response* (HAZWOPER Standard).

4.1.1.3 Code of Federal Regulations, 29CFR1910.147, *Control of Hazardous Energy* (Lockout/Tagout Standard).

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

4.1.3 U.S. Environmental Protection Agency (EPA), Governing editions:

4.1.3.1 Code of Federal Regulations, 40 CFR Part 68, *Chemical Accident Prevention Provisions* (RM Program Regulation).

4.1.3.2 Clean Air Action Section 112(r)(1), *The General Duty Clause*.

4.1.3.3 Environmental Protection Agency EPA 550-B00-002, *Guidance for Implementation of the General Duty Clause Clean Air Act Section 112(r)(1)*.

4.1.4 Environmental Canada, *Environmental Emergency Regulations under Part 8 of CEPA* latest edition (E2 Regulations).

4.1.5 International Institute of Ammonia Refrigeration (IIAR), IIAR 2 *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating* Systems

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4.2 Informative References

4.2.1 International Institute of Ammonia Refrigeration (IIAR):

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

4.2.1.2 IIAR *Process Safety Management Guidelines for Ammonia Refrigeration*, 2nd Edition.

4.2.1.3 IIAR *Ammonia Refrigeration Management (ARM) Program.*

4.2.1.4 IIAR *Introduction to Ammonia Refrigeration.*

4.2.2 Cascade Energy Engineers (with distribution support from Northwest Food Processors Association (NWFPA)), *Industrial Refrigeration Best Practices Guide.*

4.2.3 Refrigerating Engineers & Technicians Association (RETA), Industrial Refrigeration Course IV, *Plant Operations & Safety*.

SECTION 5

DEVELOPING AND MAINTAINING OPERATING PROCEDURES

5.1 Operating Procedure Contents

The following items shall be included in the operating procedures:

a. Initial start-up
b. Normal operations
c. Temporary operations
d. Normal shutdown
e. Emergency shutdown
f. Emergency Operations
g. Start-up following a turnaround, or after an emergency shutdown

Operation procedures shall describe the appropriate personal protective equipment (PPE) that shall be worn when performing work on the ammonia refrigerating system. The operating procedures shall also indicate when the buddy system shall be practiced when performing work on the system. The IIAR's *Introduction to Ammonia Refrigeration* contains a description of personal protection equipment applicable to ammonia. Developers of operating procedures shall review IIAR's *Introduction to Ammonia Refrigeration*, modify these requirements to reflect the work performed on their system, and incorporate the PPE requirements into their operating procedures. Operating procedures shall refer to the facility confined space entry procedure where appropriate.

Operating procedures shall include steps where appropriate to prevent trapping liquid ammonia when closing valves to isolate system components. Hydrostatic pressure can develop when liquids become trapped with no gases present. Whenever this is a possibility the sequence of steps shall assure that liquid has been removed from the system component to be isolated before the last isolation valve is closed.

Operating procedures shall comply with regulatory requirements. In the United States all facilities are subject to EPA's General Duty Clause requirements (Section 112(r)(l) of the Clean Air Act) and to the General Duty Clause in section 5(a)(1) of the Occupational Safety and Health Act (29 U.S.C. § 654(a)(1)). Additional items shall be included in the operating procedures if the ammonia refrigerating system is covered by OSHA's Process Safety Management (PSM) Standard (29 CFR 1910.119), the USEPA's Risk Management Program (RM Program) Regulation (40 CFR Part 68), or state regulations

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that exceed minimum requirements. Some of these additional items include:

a. System operating limits
b. Consequences of deviations, steps to take to correct and/or avoid deviations
c. Properties of and the hazards associated with ammonia
d. Quality control procedures taken to monitor the ammonia concentration, ammonia inventory levels, and the precautions necessary to prevent exposure
e. Description of safety systems and their functions
f. Safety and health considerations regarding the process

Appendix D contains an example of additional information related to regulatory compliance. Consult IIAR's *Process Safety Management Guidelines for Ammonia Refrigeration* for additional samples of operating procedures which are designed to comply with OSHA's PSM Standard.

5.2 Developing Operating Procedures

Developers of operating procedures shall consider the following documentation:

a. Material safety data sheets
b. Refrigerating system flow drawings (such as block flow diagrams) and/or piping & instrument diagrams (P&IDs)
c. Equipment lists
d. Installation, Operation and Maintenance manuals
e. Manufacturer- (or vendor-) provided instruction
f. Control system documentation
g. Operating parameters
h. Application data
i. Consider direct input of system operators or mechanics when documenting the procedures followed to operate the refrigerating system.

NOTE: Supplement manufacturer provided instructions with site specific references such as valve numbers where necessary.

5.3 Procedures for Non-Routine Tasks

When non-routine tasks are required which are not covered by normal operating procedures, facilities shall develop procedures for these specific tasks during the planning stages for these tasks. Procedures for non-routine tasks are permitted to be documented as temporary operating and/or emergency operating procedures.

5.4 Maintaining Operating Procedures

Each operating procedures shall have a document number, revision number, and/or revision date so that changes made to the operating procedure can be clearly tracked. In addition, a table of contents shall be provided if there are a significant number of distinct operating procedures.

The operators and mechanics shall be able to quickly and easily obtain current operating procedures to prepare for and perform their assigned job tasks. It is permissible for these procedures to be available as printed (hard-copy) documents, viewed on computer screens, and/or printed as needed from electronic files. The most current procedures shall be available to ensure that only up-to-date procedures are used to perform operations and maintenance tasks.

Operating procedures shall be reviewed when changes are made to the ammonia refrigerating system and the operating procedures shall be updated as appropriate.

NOTE: Certain regulations such as OSHA's Process Safety Management (PSM) Standard (29 CFR 1910.119) and the USEPA's Risk Management Program (RM Program) Regulation (40 CFR Part 68) require operating procedures to be annually certified current and accurate.

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SECTION 6

EQUIPMENT

6.1 Operating Procedure Customization

When documenting operating procedures the procedures in this section shall be customized to reflect the type and style of equipment used in the refrigerating system. The operating procedures shall also describe the appropriate personal protective equipment (PPE) that shall be worn and indicate when the buddy system shall be practiced when performing work on equipment.

6.2 Compressors

This section applies to the following compressors which are applied to closed-circuit ammonia refrigerating systems:

a. Rotary vane booster compressors
b. Reciprocating booster and high stage compressors
c. Rotary screw booster and high stage compressors
d. Centrifugal booster and high stage compressors

Appendix A contains sample operating procedures for a high (single) stage compressor.

6.2.1 Compressor initial start-up

6.2.1.1 The following items shall be considered (as applicable to the equipment) when documenting compressor start-up procedures.

a. Appropriate conditions (suction and discharge pressure and temperature, lubrication oil temperature, lubrication oil level, etc.) to ensure a safe start-up.
b. Corrective actions required if the conditions are outside of appropriate limits.
c. Lockout/tagout procedures.
d. Location of the compressor electrical disconnect.
e. Position of the compressor isolation and service valves.
f. Status of the lubrication oil cooling system.
g. Function of the compressor alarm systems.
h. Steps to start the compressor.

6.2.2 Monitoring a compressor during normal operations

6.2.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring a compressor.

a. Verify that the following compressor parameters are within expected operating limits and troubleshoot as necessary:
   i. Discharge pressure and temperature.
   ii. Suction pressure and temperature.
   iii. Oil pressure and temperature.
   iv. Oil filter pressure drop.
   v. Oil level.
b. Verify that shaft seal leakage is within the allowable limits specified by the manufacturer.
c. Verify that there are no ammonia or oil leaks from the compressor beyond allowable limits of shaft seal leakage specified by the manufacturer.
d. Verify that there are no unusual noises or vibrations.

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6.2.3 Steps required to operate a compressor under temporary operations

6.2.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating a compressor under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the compressor to operate under the temporary operating parameters.
c. Procedures to monitor the compressor while it is operated under temporary operating conditions.

6.2.4 Compressor normal shutdown

6.2.4.1 The following items shall be considered (as applicable to the equipment) when documenting compressor shut down procedures.

a. Steps to stop the compressor.
b. Steps to prepare the compressor for stand-by operations or for maintenance operations as appropriate.

6.2.5 Compressor emergency shutdown

6.2.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down a compressor in an emergency.

a. Specify who is responsible for the emergency shutdown of the compressor.
b. Steps to stop the compressor.
c. Steps to close the compressor isolation valves, turn off power to the compressor, and apply lockout/tagout devices if it is safe to do so.
d. Notification of supervisory personnel and/or the appropriate authorities.
e. Steps to log the conditions that caused the emergency shutdown.

6.2.6 Compressor emergency operations

6.2.6.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for compressor emergency operations.

a. Steps to operate the compressor under emergency operations, for example when compressor conditions are outside of appropriate limit.

6.2.7 Compressor start-up following a turnaround, or after an emergency shutdown

6.2.7.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for starting a compressor following a turnaround or following an emergency shut down.

a. Appropriate practices if the compressor will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (suction and discharge pressure and temperature, lubrication oil temperature, lubrication oil level, etc.) to ensure a safe start-up.
c. Corrective actions required if the conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Location of the compressor electrical disconnect.
f. Position of the compressor isolation and service valves.
g. Status of the lubrication oil cooling system.
h. Function of the compressor alarm systems.
i. Steps to start the compressor.

6.3 Condensers

This section applies to the following condensers which are applied to closed circuit ammonia refrigerating systems:

a. Air cooled condensers and air cooled desuperheaters.

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b. Evaporative condensers.
c. Horizontal and vertical shell and tube condensers with closed water passes and vertical shell and tube condensers with open water passes.
d. Plate heat exchanger condensers of the plate-and-shell type, and of the plate-and-frame type.
e. Double-pipe condensers with closed water passes.

6.3.1 Condenser initial start-up

6.3.1.1 The following items shall be considered (as applicable to the equipment) when documenting condenser start-up procedures.

a. Appropriate practices if the condenser will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (pressure, temperature, water flow, etc.) to ensure a safe startup.
c. Corrective action required if the conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Location of the condenser electrical disconnect.
f. Position of the condenser isolation and service valves.
g. Function of the condenser alarm systems.
h. Steps to start the condenser water flow and fans.

6.3.2 Monitoring a condenser during normal operations

6.3.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring a condenser:

a. Verify that the following condenser parameters are within expected operating limits and troubleshoot as necessary:
   i. Discharge pressure.
   ii. Water treatment limits.
   iii. Water temperature.
   iv. Sump heater (if applicable).
b. Verify that there are no ammonia or water leaks from the condenser.
c. Verify that the water supply to the condenser(s) is on and if a sump is used the water is at the proper level.
d. Verify that the level control is properly working.
e. Verify that the water pump shaft seal is not leaking.
f. Verify that there are no unusual noises or vibrations.
g. Verify the sump heater is operational.
h. Verify good water spray on coils.
   i. Verify tension on fan belts.

6.3.3 Steps required to operate a condenser under temporary operations

6.3.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating condenser under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the condenser to operate under the temporary operating parameters.
c. Steps to monitor the condenser while it is operated under temporary operating conditions.

6.3.4 Condenser normal shutdown

6.3.4.1 The following items shall be considered (as applicable to the equipment) when documenting condenser shut down procedures:

a. Steps to turn off condenser fans.
b. Steps to turn off the water pump.
c. Steps to turn off the water supply (if necessary).
d. Steps to drain the condenser sump (if necessary).
e. Steps to prepare the condenser for stand-by operations or for maintenance operations as appropriate.

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6.3.5 Condenser emergency shutdown

6.3.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down a condenser in an emergency.

a. Steps to stop vapor flow to the condenser by shutting down the appropriate compressor(s) and pressure vessels.
b. Steps to shut down the water pumps and fans (if appropriate).
c. Steps to close the condenser isolation valves and apply lockout/tagout devices if it is safe to do so.
d. Notification of supervisory personnel and/or the appropriate authorities.
e. Steps to log the conditions that cause the emergency shut down.

6.4 Evaporators

This section applies to the following evaporators which are applied to closed circuit ammonia refrigerating systems:

a. Forced air evaporator coils.
b. Shell-and-tube evaporators (with refrigerant in shell or in tubes) at any temperature level when evaporating refrigerant is used to cool another fluid.
c. Plate heat exchanger evaporators of the plate-and-shell type and of the plate-and-frame type.
d. Tube-in-tube evaporators.
e. Jacketed vessels.
f. Scraped surface heat exchangers.
g. Falling film heat exchangers.
h. Specialized heat exchangers.

6.4.1 Evaporator initial start-up

6.4.1.1 The following items shall be considered (as applicable to the equipment) when documenting evaporator start-up procedures.

a. Appropriate maintenance practices if this evaporator will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (pressure, temperature, ammonia level, etc.) to ensure a safe start-up.
c. Corrective actions required if conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Location of the evaporator electrical disconnect.
f. Position of evaporator isolation and service valves.
g. Equipment in the refrigerating system needed to accommodate this evaporator.
h. Function of the evaporator alarm systems.
i. Steps to start the evaporator.
j. Status of the process refrigerating load.

6.4.2 Monitoring an evaporator during normal operations

6.4.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring an evaporator.

a. Verify that the following evaporator parameters are within expected operating limits and troubleshoot as necessary:
   i. Suction pressure.
   ii. Suction temperature.
   iii. Ammonia level (if applicable).
   iv. Process temperature and flow.
b. Verify that there are no ammonia leaks from the evaporator.
c. Verify that there are no unusual noises or vibrations.
d. Status of the process refrigeration load.
e. Verify there is no unacceptable ice buildup on evaporator coils.

6.4.3 Steps required to operate an evaporator under temporary operations

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6.4.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating an evaporator under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the evaporator to operate under the temporary operating parameters.
c. Steps to monitor the evaporator while it is operated under temporary operating conditions.
d. Steps to monitor the process while it is operated under temporary operating conditions.

6.4.4 Evaporator normal shutdown

6.4.4.1 The following items shall be considered (as applicable to the equipment) when documenting evaporator shut down procedures.

a. Steps to shut down the evaporator.
b. Steps to shut down the process associated with the evaporator.
c. Steps to prepare the evaporator for stand-by operations or for maintenance operations as appropriate.

6.4.5 Evaporator emergency shutdown

6.4.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down an evaporator in an emergency.

a. Steps to shut down the evaporator.
b. Steps to discontinue process operations.
c. Steps to close the evaporator isolation valves, turn off power to the evaporator, and apply lockout/tagout devices if it is safe to do so.
d. Notification of supervisory personnel and/or the appropriate authorities.
e. Steps to log the conditions that cause the emergency shut down.

6.4.6 Defrosting an evaporator

6.4.6.1 The following items shall be considered (as applicable to the equipment) when documenting procedures to defrost an evaporator.

a. Defrost method: air, water, hot gas, or electric.
b. The frequency of the defrost cycles
c. The method used to initiate a defrost cycle (for example manually initiated or initiated using a timer).
d. The specific sequence of steps associated with the defrost cycle.
e. Controls and instruments associated with the defrost cycle.
f. Pressures during the defrost cycle.
g. Precautions necessary to prevent thermal shock during the defrost cycle.
h. Process parameters and status.

6.5 Pressure Vessels

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

6.5.1 Pressure vessel initial start-up

6.5.1.1 The following items shall be considered (as applicable to the equipment) when documenting pressure vessel start-up procedures.

a. Appropriate practices if the pressure vessel will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (pressure, ammonia level, etc.) to ensure a safe start-up.
c. Corrective actions required if the conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Position of all pressure vessel isolation and service valves.
f. Function of the pressure vessel alarm systems.
g. Steps to bring the appropriate equipment on line.

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6.5.2 Monitoring a pressure vessel during normal operations

6.5.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring a pressure vessel.

a. Verify that the following pressure vessel parameters are within expected operating limits and troubleshoot as necessary:
   i. Pressure.
   ii. Liquid level.
b. Verify that there are no ammonia leaks from the pressure vessel.

6.5.3 Steps required to operating a pressure vessel under temporary operations

6.5.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating the pressure vessel under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the pressure vessel to operate under the temporary operating parameters.
c. Steps to monitor the pressure vessel while it is operated under temporary operating conditions.

6.5.4 Pressure vessel normal shutdown

6.5.4.1 The following items shall be considered (as applicable to the equipment) when documenting pressure vessel shut down procedures.

a. Steps to stop the flow to the pressure vessel by shutting down the appropriate equipment such as compressor(s), condenser(s), and evaporator(s).
b. Steps to shut off the liquid make-up system (if necessary).
c. Steps to close isolation valves to stop liquid migration (if necessary).
d. Steps to prepare the pressure vessel for stand-by operations or for maintenance operations as appropriate.

6.5.5 Pressure vessel emergency shutdown

6.5.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down a pressure vessel in an emergency.

a. Steps to minimize the magnitude or duration of the emergency. The specific steps will be dependent on the emergency situation that is occurring.
b. Steps to close the pressure vessel isolation valves and apply lockout/tagout devices when it is safe and appropriate to do so.
c. Notification of supervisory personnel and/or the appropriate authorities.
d. Steps to log conditions that cause the emergency shut down.

6.6 Refrigerant Pumps

This section applies to mechanical pumps applied for use in closed circuit ammonia refrigerating systems. This section does not apply to transfer procedures which are addressed in Section 8.2.

6.6.1 Refrigerant pump initial start-up

6.6.1.1 The following items shall be considered (as applicable to the equipment) when documenting pump start-up procedures.

a. Appropriate practices if the pump will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (suction pressure, discharge pressure, etc.) to ensure a safe start-up.
c. Corrective actions required if conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Location of the pump electrical disconnect.
f. Position of pump isolation and service valves.

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g. Function of the pump alarm systems.
h. Steps to start the pump.
i. Process status.
j. Minimum flow.
k. Hydrostatic relief.
l. Motor cooling.

6.6.2 Monitoring a refrigerant pump during normal operations

6.6.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring a pump.

a. Verify that the following pump parameters are within expected operating limits and troubleshoot as necessary:
   i. Discharge pressure.
   ii. Suction pressure.
b. Verify that there is no leakage from the pump seals.
c. Verify that there are no leaks from flanges or pipe connections.
d. Verify that there are no unusual noises or vibrations.

6.6.3 Steps required to operating a refrigerant pump under temporary operations

6.6.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating a pump under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the refrigerant pump to operate under the temporary operating parameters.
c. Steps to monitor the refrigerant pump while it is operated under temporary operating conditions.

6.6.4 Refrigerant pump normal shutdown

6.6.4.1 The following items shall be considered (as applicable to the equipment) when documenting pump shut down procedures.

a. Steps to stop the pump.
b. Steps to prepare the pump for stand-by operations or for maintenance operations as appropriate.
c. Steps to secure process operations.

6.6.5 Refrigerant pump emergency shutdown

6.6.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down a pump in an emergency.

a. Steps to stop the pump.
b. Steps to close the pump isolation valves, turn off power to the pump, and apply lockout/tagout devices if it is safe to do so.
c. Notification of supervisory personnel and/or the appropriate authorities.
d. Steps to log the conditions that caused the emergency shut down.
e. Steps to secure process operations.

6.7 Non-Condensable Gas Purger

This section applies to non-condensable gas purgers applied for use in closed circuit ammonia refrigerating systems. This section does not apply to manual purging of non-condensables from the system which is addressed in Section 8.3.

6.7.1 Non-condensable gas purger initial start-up

6.7.1.1 The following items shall be considered (as applicable to the equipment) when documenting purger start-up procedures.

a. Appropriate practices if the purger will be started following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (foul gas pressure, purge point timing, etc.) to ensure a safe system start-up.

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c. Corrective actions required if the conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Location of the purger electrical disconnect.
f. Position of the purger isolation and service valves.
g. Function of the purger alarm systems.
h. Steps to start the water supply to the purger.
i. Steps to start the purger.

6.7.2 Monitoring a non-condensable gas purger during normal operations

6.7.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for monitoring a purger.

a. Verify that the following purger parameters are within expected operating limits and troubleshoot as necessary:
   i. Water supply.
   ii. Timing and duration of purge points.
   iii. Incoming foul gas pressure at each incoming line.
   iv. Condition of solenoid valve coils.
   v. Purge count (if applicable).
b. Verify that there is no leakage from the purger.
c. Check the ammonia concentration in the area in/around the purger.

6.7.3 Steps required to operating a non-condensable gas purger under temporary operations

6.7.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating a purger under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the purger to operate under the temporary operating parameters.
c. Steps to monitor the purger while it is operated under temporary operating conditions.

6.7.4 Non-condensable gas purger normal shutdown

6.7.4.1 The following items shall be considered (as applicable to the equipment) when documenting purger shut down procedures.

a. Steps to stop the purger.
b. Steps to prepare the purger for stand-by operations or for maintenance operations as appropriate.

6.7.5 Non-condensable gas purger emergency shutdown

6.7.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down a purger in an emergency.

a. Steps to stop the purger.
b. Steps to close the purger isolation valves, turn off power to the purger, and apply lockout/tagout devices if it is safe to do so.
c. Notification of supervisory personnel and/or the appropriate authorities.
d. Steps to log the conditions that caused the emergency shut down.

6.8 Oil Removal Devices

This section applies to the following oil removal devices which are applied to closed circuit ammonia refrigerating systems:

a. Individual oil collecting pots
b. Multiple point oil collecting pots
c. Central oil pump out systems

6.8.1 Oil removal device initial start-up

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6.8.1.1 The following items shall be considered (as applicable to the equipment) when documenting procedures to set-up an oil removal device.

a. Appropriate practices if the oil removal device will be used following general maintenance, emergency shut down or after a system modification.
b. Appropriate conditions (system pressure, device pressure, etc.) to ensure a safe operation.
c. Corrective actions required if the conditions are outside of appropriate limits.
d. Lockout/tagout procedures.
e. Need for personal protection equipment.
f. Emergency response procedures.
g. Location of safety shower and eyewash stations.
h. Position of isolation and service drain valves.
i. Function of the oil removal device alarm systems (as applicable to the equipment).
j. Type of oil removal device.

6.8.2 Operating an oil removal device during normal operations

6.8.2.1 The following items shall be considered (as applicable to the equipment) when documenting procedures to drain oil from the system to the oil removal device.

a. Position of isolation and service drain valves.
b. Sequence of steps to drain oil from the system.
c. Amount of time needed to drain the oil.
d. System pressure.
e. Oil removal device pressure.
f. Steps to use auxiliary equipment such as a pump-out system (if necessary).
g. System being drained.

6.8.2.2 The following items shall be considered (as applicable to the equipment) when documenting procedures to draining oil from the oil removal device.

a. Position of isolation and service drain valves.
b. Steps to operate auxiliary heating systems (if necessary).
c. Sequence of steps used to minimize the amount of residual ammonia in the oil.
d. Sequence of steps to drain oil from the system.
e. Amount of time needed to drain the oil.
f. Oil removal device pressure.
g. Steps to use auxiliary equipment such as a pump-out system (if necessary).
h. Steps to maintain an oil log.
i. Steps to dispose of the oil removed from the system.

6.8.3 Steps required to operating an oil removal device under temporary operations

6.8.3.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for operating an oil removal device under temporary operating parameters.

a. Steps to consult supervisory personnel to establish temporary operating parameters.
b. Steps to modify the oil removal device to operate under the temporary operating parameters.
c. Steps to monitor the oil removal device while it is operated under temporary operating conditions.

6.8.4 Oil removal device normal shutdown

6.8.4.1 The following items shall be considered (as applicable to the equipment) when documenting oil removal device shut down procedures.

a. Steps to return the device to standby mode.
b. Position of isolation and service drain valves.
c. Steps to turn off auxiliary equipment such as a pump-out system (if necessary).
d. Steps to verify there are no ammonia leaks.

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6.8.5 Oil removal device emergency shutdown

6.8.5.1 The following items shall be considered (as applicable to the equipment) when documenting procedures for shutting down an oil removal device in an emergency.

a. Steps to shut down the oil removal device.
b. Steps to close the oil removal device isolation valves, turn off power to the oil removal device, and apply lockout/tagout devices if it is safe to do so.
c. Notification of supervisory personnel and/or the appropriate authorities.
d. Steps to log the conditions that caused the emergency shut down.

SECTION 7

SYSTEMS

7.1 This section lists items which shall be considered when combining procedures for individual pieces of equipment into operating procedures for the entire refrigerating system.

7.2 When developing operating procedures for the entire refrigerating system or for refrigerating subsystems the following items shall be considered:

a. Type and style of equipment used in the refrigerating system.
b. Refrigerating system configuration.
c. The sequence in which they will be operating.
d. If one procedure can be used for all of the equipment or whether multiple procedures must be developed for individual pieces of equipment.

7.3 Additional guidelines are contained in the attached Informative Appendix B.

SECTION 8

TASKS

8.1 Daily Rounds/System Logs and Troubleshooting:

8.1.1 This section applies to closed circuit ammonia refrigerating systems. Equipment covered by this section includes compressors, pressure vessels, pumps, heat exchangers and sub-systems with related component.

8.1.2 The operating procedures shall document the following items:

a. System operating ranges for the refrigerating system parameters such as pressures, levels and temperatures.
b. Steps to take to respond to a system upset, for example if the pressure begins to rise outside its normal range or if a leak occurs.

8.2 Liquid Management

8.2.1 This section applies to the following procedures:

a. Charging of the system.
b. Procedures to transfer ammonia within the system.

8.2.2 The operating procedures for charging of the system shall document the following items:

a. The appropriate personal protective equipment (PPE) that shall be worn and indicate when the buddy system shall be practiced.
b. The source of the refrigerant, i.e. charge from a cylinder or from a truck.
c. Charging point on the system.

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d. Facility safe work practices and emergency action and response plan procedures applicable to the charging procedures.
e. Steps required to charge ammonia to the system.
f. Steps required to purge the charging system.
g. Visually inspect hoses fittings, etc. and make sure they are suitable for ammonia refrigeration service.

8.2.3 The operating procedures for transferring ammonia within the system shall document the following items:
a. The appropriate personal protective equipment (PPE) that shall be worn and indicate when the buddy system shall be practiced.
b. The conditions required for the transfer.
c. The source and the receiving location for the ammonia.
d. Steps required to transfer the ammonia.
e. Steps required to terminate the transfer of ammonia.
f. Visually inspect hoses fittings, etc. and make sure they are suitable for ammonia refrigeration service.

8.3 Manual Purging of Non-Condensables from the System

8.3.1 The operating procedures for the manual purging of non-condensables from the system shall document the following items:
a. Notification of supervisory personnel and/or the appropriate authorities.
b. The appropriate personal protective equipment (PPE) that shall be worn and indicate when the buddy system shall be practiced.
b. The conditions under which manual purging is required.
c. Location where non-condensables will be purged from the system.
d. Steps required to purge non-condensables from the system.
f. Steps required to place the system back in normal operations.

8.4 Pump-Out and Line/Equipment Opening Procedures

8.4.1 The operating procedures for the pump-out and line/equipment opening shall document the following items:
a. The appropriate personal protective equipment (PPE) that shall be worn and indicate when the buddy system shall be practiced.
b. The conditions under which pump-out and/or line/equipment opening are required.
c. Location of the line/equipment that will be pumped-out and/or opened.
d. Facility safe work practices and emergency action and response plan procedures applicable to the line/equipment opening procedures.
e. Steps required to pump-out the line/equipment.
f. Steps required to open the line/equipment.
g. Steps required to place the system back in normal operations.

8.4.2 Appendix C contains sample line opening procedures.

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Section 9

Sources of References (Informative)

9.1 American National Standards Institute (ANSI)
25 West 43rd Street, 4th Floor
New York, NY 10036

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

9.3 Industrial Efficiency Alliance
309 SW 6th Avenue, Suite 1000
Portland, OR 97214

9.4 International Institute of Ammonia Refrigeration (IIAR)
1001 North Fairfax Street, Suite 503
Alexandria, VA 22314

9.5 Refrigerating Engineers & Technicians Association (RETA)
PO Box 1819
Salinas, CA 93902

9.6 U.S. Environmental Protection Agency (EPA)
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460

9.7 U.S. Department of Labor/OSHA
Publications Department
200 Constitution Avenue, NW, Room N3101
Washington, DC 20210

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APPENDIX A (INFORMATIVE)

EQUIPMENT SOP SAMPLE — SOP 1: HIGH (SINGLE) STAGE COMPRESSOR

Objective
This procedure contains Standard Operating Procedures (SOP) for the operation of a screw compressor.

Purpose
The purpose of the SOP is to establish the proper steps for startup, operation, and shutdown of the compressor.

Concerns
Careful attention to suction and discharge pressure and temperature, and lubrication oil temperature are important to this procedure because compressor damage can occur when compressors are dead-headed or when lubrication is lost. Among the incidents we are trying to prevent are:

- Injury to operator(s)
- Damage to compressors due to high discharge pressure or loss of lubrication
- Overpressurization of the refrigeration system (e.g., blocked in liquid) resulting in a release through pressure relief valves or failure or rupture of lines, tubes, or other equipment and a subsequent release, for example due to trapped liquid in the liquid injection line.

Caution
- Use lockout/tagout procedures as required
- Continuously check for leaks
- Wear proper PPE when performing procedures
- Obtain line break permit as necessary
- Use buddy system as required
- Have emergency response equipment available, but not in work area

Initial development date
June 14, 2009

Revision
No. 1

A.1 Compressor Initial Start-up

The following procedures should be used during normal (manual) start-ups of the compressor and for start-ups following general maintenance operations.

A.1.1 Remove any lockout/tagout devices or tags from the compressor.

A.1.2 Verify that the evaporative condenser is fully operational.

A.1.3 Verify that the "pump-down" valve on the discharge line on the compressor is closed (Valve # ___) and that all vent and drain lines contain plugs or caps.

A.1.4 Verify that the relief valves associated with the compressor are in place and that the three-way valve for the relief valves is fully open to one of the relief valves.

A.1.5 Manually open the suction valve (full open) to the compressor (Valve # ___). Inspect for and fix any ammonia leaks.

A.1.6 Manually open the discharge valve from the compressor (Valve # ___).

A.1.7 Manually open the manual valves on the liquid injection cooling line (Valves # ___ and # ___) and verify that the solenoid valve is in its correct operating position.

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A.1.8 Verify the oil level in the compressor using the two sight glasses. The level should be in the middle of the top sight glass when the compressor is shut down. The level should be in the middle of the bottom sight glass when the compressor is running.

A.1.9 Verify that the compressor coupling guard is in place.

A.1.10 Remove any locks and tags and turn on power to the compressor.

A.1.11 Use the microprocessor to ensure that the oil temperature in the oil separator is above 110°F. If the oil temperature is not above 110°F check the oil heater.

A.1.12 Press the "Local Start" button on the microprocessor.

A.1.13 Press the "Automatic" button on the microprocessor. The compressor oil pressure will begin to increase as the lubrication pump starts-up. Once the oil pressure has built up, the compressor will start.

A.1.14 Monitor analog data on the microprocessor to verify that all the parameters are within the acceptable range.

A.1.15 Monitor the system for ammonia/oil leaks. Shutdown the compressor (see task 4) if any leaks are observed.

A.2 Monitoring a Compressor During Normal Operations

The following procedures should be used to monitor the compressor during normal operations. During normal operations, the compressor is automatically started and stopped and automatically loaded and unloaded based on suction pressure.

A.2.1 Conduct rounds to visually inspect the compressor at least once every _____ hours to verify that the following compressor parameters are within expected operating limits:

- Suction pressure: Verify the position of the suction valve and adjust settings using the compressor microprocessor
- Discharge pressure: Verify the position of the discharge valve and verify the operation of the evaporative condenser
- Lubrication oil pressure and temperature, discharge temperature: Verify the operation of the lubrication oil pump, the position of the oil valves, the oil filter pressure drop and the operation of liquid injection system
- Verify that there are no mechanical problems with the compressor.

A.2.2 Shutdown the compressor (see task 5) if any of the following conditions occurs:

- Shaft seal leakage is not within the allowable limits specified by the manufacturer
- Ammonia or oil leaks beyond allowable limits of shaft seal leakage specified by the manufacturer
- Unusual noises or vibrations

A.2.3 The compressor log sheet should be filled out once a _____.

A.3 Steps Required to Operate a Compressor Under Temporary Operations

Typically the settings are not adjusted for the compressors. Use the following procedures if any adjustments are necessary.

A.3.1 Consult the refrigeration supervisor to determine what adjustments are necessary.

A.3.2 Adjust the settings as necessary using the compressor microprocessor. The manufacturer's equipment manual should be consulted for the specific procedures necessary to adjust the settings.

A.3.3 Record any setting changes using the computer and/or the log book in the control room.

A.3.4 Follow the procedures in section A.2 to monitor the compressor while it is operated using these settings.

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A.4 Compressor Normal Shutdown

The following procedures should be used during normal (manual) shutdowns of the compressor. Steps A.4.4 to A.4.13 should only be followed if maintenance is to be performed on the compressor Section A.5 should be used for emergency shutdown procedures.

A.4.1 Push the "manual unload" button on the compressor microprocessor.

A.4.2 While the compressor unloads, monitor the compressor temperatures and pressures and look/listen for any unusual vibrations.

A.4.3 Monitor the load percentage until it reaches 0%, then push the "Stop/Reset" button to stop the compressor.

A.4.4 Close, "tag", and lock the manual valve located in the compressor suction line. (Valve # ___).

A.4.5 Close, "tag", and lock the manual valve located in the compressor discharge line. (Valve # ___).

A.4.6 Close, "tag", and lock the manual valves located in the compressor liquid injection line. (Valves # ___ and # ___).

A.4.7 Connect a hose that is appropriate for ammonia service from the "pump down" valve located on the compressor to the service valve on the low pressure suction header (Valve # ___).

A.4.8 Open the service valve (Valve # ___) on the low pressure suction header and the "pump down" valve on the compressor (Valve # ___) allowing the low pressure suction header to evacuate residual ammonia from the compressor to the refrigeration system.

A.4.9 Evacuate the residual ammonia from the compressor, until the pressure gauge located at the service port of the low pressure suction header reads 0 psig.

A.4.10 Close the valve on the service port to the low pressure suction header (Valve # ___) and monitor the pressure gauge on the service port at the low pressure suction header for any pressure increases (above 0 psig).

A.4.11 After 15 minutes, close the "pump out" valve on the compressor (Valve # ___). Remove the pressure gauge and slowly reopen the "pump out" valve on the compressor to break the vacuum.

A.4.12 Open, lock and "tag" the compressor disconnect to lock out power to the compressor.

A.4.13 At this point ammonia should be removed from the compressor and the compressor should be fully locked out. Follow appropriate line opening procedures to perform maintenance on the compressor. Wear appropriate personal protective equipment (PPE) and follow the buddy system.

A.5 Compressor Emergency Shutdown

The following procedures should be used by qualified, trained personnel to shutdown the compressor during an emergency. Use these procedures if there are leaks on the compressor skid or if there is any mechanical damage to the compressor. These procedures are only guidelines to supplement the emergency response procedures. Each emergency situation should be evaluated on a case-by-case basis to determine the actual emergency response procedures to follow.

A.5.1 Practice the buddy system and do not put yourself at risk during any emergency. If an area cannot be safely entered, leave the area and wait for assistance before proceeding.

A.5.2 Verify that the ventilation fans in the machinery room are operating.

A.5.3 Verify that you know the escape routes to take.

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A.5.4 Assemble the appropriate general protective equipment. Protective equipment that may be required includes:

- Goggles;
- Full face shield;
- Chemical resistant gloves (rated for appropriate temperature levels);
- Chemical resistant boots;
- Emergency showers/eye wash stations;
- First aid kit;
- Full face gas mask;
- Positive pressure self-contained breathing apparatus;
- Chemical resistant suits (rated for ammonia use);
- 2-way radios; and
- Hearing protection (earplugs).

A.5.5 Assemble the appropriate tools. Tools that may be required include:

- Rescue rope;
- Non-sparking pipe wrench;
- Ammonia rated purge hose;
- Portable monitoring equipment;
- Explosion-proof flashlight(s);
- Water hose with mist nozzle; and
- Portable ventilation fans.

A.5.6 Measure the ammonia concentration at the door and follow the personal protective equipment (PPE) requirements in the Emergency Response Plan before walking into any room. No area should be entered if there is a visible ammonia cloud.

A.5.7 Shut off the compressor by hitting the "Emergency Stop" button on the microprocessor control panel. If the button cannot be safely reached due to the ammonia concentration inside the compressor room, use the "Emergency Stop" button located at the entrance to the compressor room.

A.5.8 Close, "tag", and lock the manual valve located in the compressor suction line. (Valve # ___).

A.5.9 Close, "tag", and lock the manual valve located in the compressor discharge line. (Valve # ___).

A.5.10 Close, "tag", and lock the manual valves located in the compressor liquid injection line. (Valves # ___ and # __).

A.5.11 Open, lock and "tag" the compressor disconnect to lock out power to the compressor.

A.6 Compressor Emergency Operations

The following procedures should be used by qualified, trained personnel to operate the compressor during an emergency, for example when compressor conditions are outside of appropriate limits. Each emergency situation should be evaluated on a case-by-case basis to determine the actual emergency operations to follow.

A.6.1 Consult the refrigeration supervisor to determine what adjustments are necessary.

A.6.2 Adjust the settings as necessary using the compressor microprocessor. The manufacturer's equipment manual should be consulted for the specific procedures necessary to adjust the settings.

A.6.3 Record any setting changes using the computer and/or the log book in the control room.

A.6.4 Follow the normal operating procedures (see task 2) to monitor the compressor while it is operated using these settings.

A.6.5 Shutdown the compressor (see task 5) if any of the following conditions occurs:

- Shaft seal leakage is not within the allowable limits specified by the manufacturer
- Ammonia or oil leaks beyond allowable limits of shaft seal leakage specified by the manufacturer
- Unusual noises or vibrations

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A.7 Compressor Start-Up Following a Turnaround or After an Emergency Shutdown

The following procedures should be used during start-ups of the compressor following turnarounds or after an emergency shutdown.

A.7.1 Determine (and correct if necessary) any problems before restarting the system following an emergency shutdown

A.7.2 Follow pre-startup procedures for the compressor as appropriate, for example vacuum and/or pressure tests. Consult IIAR 5 *Start-up and Commissioning of Closed-Circuit Ammonia Mechanical Refrigerating Systems* for examples of initial start-up procedures when commissioning new equipment.

A.7.3 Follow the compressor initial start-up procedures (step 1) to start-up the compressor.

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APPENDIX B (INFORMATIVE)

DISCUSSION — SYSTEM SOP

B.1 Skid packages

B.1.1 The simplest mechanical refrigerating systems are small, skid packages. A typical skid package may include a compressor, a condenser, one or two pressure vessels, and one evaporator. Pieces of equipment in a skid package are typically not started up and shut-down piecemeal. Instead, there is typically a single series of steps to start-up the entire skid package rather than steps to start-up individual components within the system.

B.1.2 The written procedures for skid packages often reflect this mode of operation. Typically separate procedures are not written for each piece of equipment in the system. It is acceptable practice to develop one "system" procedure which simultaneously incorporates all pieces of equipment. This system procedure often includes the series of steps required to start-up and shutdown the entire package. For example, the system start-up procedures may include steps to start up the condenser, steps to start-up the compressor, steps to start-up the pressure vessels along with steps to start up the evaporator in a single "start-up" procedure. System operating, shut down, emergency shut down, and temporary procedures are typically also developed.

B.2 Complex refrigerating systems

B.2.1 Most mechanical refrigerating systems are larger and more complex than simple skid packages. In complex systems individual pieces of equipment need to be started and stopped separately in varying degrees of urgency as loads shift in the system. For example individual compressors may need to be started and stopped as loads increase and decrease in the system. Operators should also identify applicable activities which may require the operation of several different system components. For example, starting the refrigeration system may require operators to simultaneously conduct tasks related to compressors, evaporators, vessels, pumps, and other equipment.

B.2.2 The written procedures for complex systems typically reflect this mode of operation. For complex systems separate procedures are often developed for each piece of equipment in the system. For example, one set of operating procedures may be written for the compressors. A separate set of procedures may be developed for the condensers, the pressure vessels, etc. Each of these sets of operating procedures typically contains the items described in Section 6 Other activities require the consideration of the effects on the entire system. In these cases it may be difficult to meaningfully categorize procedures by equipment alone, and therefore procedures should be written for system activities in conjunction with procedures for each piece of equipment. Each of these sets of operating procedures typically contains the items described in Sections 7 and 8.

B.2.3 When documenting procedures for complex systems decisions need to be made on how to handle similar pieces of equipment. The key question is whether to develop individual procedures for each piece of equipment or whether to combine multiple pieces of similar equipment into a single procedure. The following criteria may be used to aid in these decisions:

a. A single procedure may be developed if the similar equipment is identical, i.e. compressors of the same manufacturer and model number with identical operating procedures.
b. A single procedure may be developed even if the similar equipment is not identical provided that the differences between the similar equipment are accounted for in the operating procedures. For example a single

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procedure may be written for all compressors of the same manufacturer even if the system contains multiple compressor models provided that the compressors are in similar service (e.g. all high stage compressors). Methods that can be used to account for the differences include:

i. Using tables to list the specific valve numbers for each piece of equipment.
ii. Providing "Notes" in the procedures which describe steps needed to operate a specific piece of equipment.
iii. Add additional sections to the procedures which contain steps for a specific piece of equipment, for example procedures to operate a swing compressor.

c. Separate procedures are often developed if the equipment is not similar (for example reciprocating compressors vs. screw compressors) or if the equipment is not in similar service (for example high stage compressors vs. booster compressors).
d. Separate procedures are typically developed if the equipment is located in separate refrigerating systems which are not interconnected.

B.2.4 The following practices are often followed when documenting procedures for complex systems.

a. Procedures for refrigerant pumps are often combined with the procedures for the vessel associated with the pump.
b. Separate procedures are typically not written for instrumentation. Instrumentation is typically included in the procedure for the specific piece of equipment associated with that instrumentation. For example, a pressure vessel procedure would include instrumentation associated with the pressure vessel level control systems.
c. Oil draining procedures are typically included with the equipment where the oil is drained from.
d. Pressure vessels associated with evaporators in flooded systems are often combined with the evaporators into a single procedure.
e. Procedures for systems with secondary refrigerants (such as glycol chillers) are typically included with the procedures for the evaporators associated with the secondary refrigerant.
f. Separate procedures are typically developed for the carbon dioxide equipment in an ammonia/carbon dioxide cascade refrigerating system.

B.2.5 System- wide operating procedures are typically developed for complex systems in addition to the procedures developed for the individual pieces of equipment. Examples of system- wide operating procedures that are typically developed include:

a. Start-up procedures following a system- wide outage, for example following a planned system shut-down or turnaround.
b. Start-up procedures following a system- wide emergency shut-down.
c. Operating procedures during and after a system-wide power outage.
d. Shut-down procedures for a system- wide shut-down, for example a planned turnaround.
e. Emergency shut-down and operating procedures for the entire system, for example following a large ammonia release or a natural disaster.

B.2.6 System- wide controls may be included in the procedures developed for the individual pieces of equipment or may merit separate dedicated procedures. Examples of system wide-controls include:

a. Master hot gas outlet pressure control regulators.
b. Emergency pressure control systems.
c. Ammonia detection systems.
d. Ammonia ventilation systems
e. Ammonia pressure relief systems.

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APPENDIX C (INFORMATIVE)

SAMPLE LINE OPENING PROCEDURES

Objective

This procedure contains general line opening procedures for a specific piece of equipment for maintenance. Line opening procedures for larger sections of the system, such as long insulated liquid lines, may be more complex and require longer evacuation time

Purpose

The purpose of the procedures is to establish the proper steps for isolating and then opening a piece of equipment or a line in the ammonia refrigerating system prior to maintenance.

Concerns

Careful attention to the temperature, pressure and amount of ammonia in the equipment or line which is being isolated. Among the incidents we are trying to prevent are:

- Injury to operator(s)
- Overpressurization of the refrigeration system (e.g., blocked in liquid) resulting in a release through pressure relief valves or failure or rupture of lines, tubes, or other equipment and a subsequent release

Initial development date

June 14, 2009

Revision

No. 1

C.1 Line Opening Procedures

C.1.1 Verify that you know the location of the nearest eye wash/safety shower station.

C.1.2 Verify that you know the location of all valves that would be required to isolate the equipment in the event of a problem.

C.1.3 Verify that the ventilation fans in the area are operating.

C.1.4 Verify that you know the escape routes to take in case of an ammonia release.

C.1.5 Assemble the appropriate general protective equipment. Protective equipment that may be required includes:

- Goggles;
- Full face shield;
- Chemical resistant gloves (rated for appropriate temperature levels);
- Chemical resistant boots;
- Emergency showers/eye wash stations;
- First aid kit;
- Full face gas mask;
- 2-way radios; and
- Hearing protection (earplugs).

C.1.6 Follow lockout/tagout procedures to lock and tag all motors associated with the equipment.

C.1.7 Close, lock and tag a valve in the supply line to isolate the equipment/line you are trying to evacuate. The valve should be located as close to the equipment/line as possible.

C.1.8 Verify there are no other lines connected to equipment/line to be evacuated. Close, lock and tag valves in these lines if necessary.

C.1.9 Allow the equipment/line to evacuate as long as possible using the suction line. Try to evacuate until there is no more frost on the line and/or the pressure drops to approximately 0 psig.

C.1.10 After the equipment/line is evacuated, completely isolate the line by closing, locking, and tagging the valve in the suction line.

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C.1.11 If possible, conduct a pressure test by attaching a pressure gauge and monitoring the pressure to verify that the pressure is not increasing above 0 psig.

C.1.12 Verify that the line is not cold — this will let you know it is evacuated.

C.1.13 **Slowly** vent the line/equipment at the best place possible so you can isolate it quickly if necessary. For example, use a vent line where possible to vent residual ammonia into a container of water to minimize any ammonia smell.

C.1.14 The system is now ready for maintenance operations.

C.1.15 When placing the equipment/line back in service after maintenance operations, conduct a pressure test the system by opening a valve in the suction line. Then work backwards, opening the suction valve(s) first and finally the valve(s) in the supply line.

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APPENDIX D (INFORMATIVE)

EXAMPLE OF ADDITIONAL INFORMATION WHICH MAY BE NEEDED FOR REGULATORY COMPLIANCE

EQUIPMENT SOP SAMPLE – SOP 1: HIGH (SINGLE) STAGE COMPRESSOR

Revision Table

Rev. #	Description of Change	Date	Revised By
0	Initial issue	11/17/2011	

Objectives and Purpose

Objective	This procedure contains the Technical Operating Specifications (TOS) and Standard Operating Procedures (SOPs) which describe the operation of the compressor.
Purpose	The purpose of the TOS is to provide a description of the compressor defining its function, operating conditions and limits, consequences of deviations from operating limits, controls, instrumentation and safety systems. The purpose of the SOP is to describe the proper steps for startup, operation and shutdown of the compressor.

Department and Equipment Information

Department	Refrigeration
Operator/ Responsibility	Refrigeration Operator
Equipment	Compressor HS-1
Location	The compressor is located in the ammonia machinery room
Related documents	Anhydrous Ammonia Material Safety Data Sheet (MSDS) [SDS upon adoption of Global Harmonization System (GHS)] Lockout/Tagout Procedures P&ID R-01 Compressor IOM Manual

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Safety and Health Consideration

Hazards and Properties of Ammonia	Ammonia is a colorless gas or liquid with an extremely pungent odor. At 0 psig (0 bar gage) It is a gas at room temperature and has a boiling point of -28°F (-33°C) and a freezing point of 108°F (-78°C). When ammonia is in its vapor phase, it is lighter than air and has a vapor density of 0.60 (Air = 1). When ammonia exists as an aerosol, it is heavier than air (vapor density >1.0). Ammonia is considered a high health hazard. If inhaled, it is pungent and can be suffocating. However, because of ammonia's low odor threshold and pungent odor, people will seek relief from its effects at relatively low concentrations. Contact of vapors or liquid can cause skin burns and eye irritation. Ammonia has fire and explosion limits of 15- 16% to 25- 28% if a source of ignition is present.
Ammonia Safety Precautions	Wear appropriate gloves and splash goggles (and potentially a face shield) when performing work where there is the potential that ammonia could be released, for example during oil draining procedures. Have respiratory protective equipment available as a back-up. Use the buddy system on all procedures where specified.
Ammonia First Aid	In case of eye contact: Flush eyes with water for at least 15 minutes and seek medical attention if necessary. In case of skin contact: Wash affected skin areas thoroughly with water for at least 15 minutes and seek medical attention if necessary. In case of inhalation: Remove subject to uncontaminated area and seek medical attention if necessary.
Inventory and Quality Control Measures	Ammonia inventory and quality control procedures are contained in a separate operating procedure.
Additional Hazards	Suction pressure, discharge pressure, and lubrication oil temperature are important to this procedure because compressor damage can occur when compressors are deadheaded (discharge flow stopped while the compressor is still running) or when lubrication is lost. Among the incidents we are trying to prevent are: • Injuries to operator(s) • Damage to compressors due to high discharge pressure or loss of lubrication • Overpressurization of the refrigeration system (e.g., blocked in liquid) resulting in a release through pressure relief valves or failure or rupture of lines, tubes, or other equipment and a subsequent release

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Compressor Technical Operating Specifications (TOS): Function

Vapor from the intercooler provides suction for the high stage compressor. During the compression phase in the compressor, the temperature of the ammonia vapor rises as the pressure of the ammonia vapor increases. The high pressure ammonia vapor flows from the compressor via a vapor header to the evaporative condenser where heat is removed, condensing the vapor into a high pressure liquid.

Compressor TOS: Capacity/Size

Description	Identification Number	Capacity/Size
Compressor	HS-1	600 TR 700 Hp
Compressor Oil Separator	National Board Number: 123456 Serial Number: 123456	2 ft diameter x 8 ft overall length

Compressor TOS: Operating Limits

Operating Limits	Deviations/Consequences	Steps to Correct/Avoid Deviations
Discharge (head) pressure in summer: 150 to 185psig Discharge (head) Pressure in winter: 100 to 160 psig Maximum discharge (head) pressure: 190 psig	Low discharge pressures could affect system efficiency. High discharge pressures could potentially damage a compressor and/or lead to an ammonia release from pressure relief valves.	Check the evaporative condenser fans and start/stop fans as necessary. Check the cooling water pumps and start/stop pumps as necessary. Check the cooling water levels in the condenser sumps and the common make-up tank. Check to make sure the auto purger is operating properly.
Suction pressure: 23 to 26 psig	Higher and lower suction pressures affect system temperatures and system efficiency (and possible compressor damage).	Check the number of compressors operating and start/stop compressors as necessary. Check the capacity control system on the compressor. Check the system loads to determine if equipment has been started, stopped, or defrosted.

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Lubrication oil pressure: 35 to 45 psig	Higher or lower lube oil pressures could damage the compressor.	Check the lube oil levels to ensure there is enough oil and to make sure that the oil is not foaming (because there is ammonia in the oil). Check to make sure that the lube oil pump is working properly. Check the lube oil filter to make sure it is not plugged.
Lubrication oil temperature: 110 to 140°F	Higher or lower lube oil temperatures could damage the compressor.	Check the SOC cooling system to make sure it is operating properly.
Compressor lubrication oil level: level should be between the middle of the upper sight glass and the bottom of the lower sight glass.	Higher or lower lube oil levels could damage the compressor.	Add/drain lubrication oil as necessary. Check to make sure that the oil is not foaming (because there is ammonia in the oil).

Compressor TOS: Controls and Instrumentation

Description	Function	Position/Setpoint
Compressor microprocessor	The compressor is automatically loaded/unloaded and started/stopped by the compressor microprocessor based on the suction pressure.	24 psig

Compressor TOS: Safety Systems

Description	Function	Position/Setpoint
Pressure relief valves (RV-001, RV-002)	Relieve excess ammonia vapor pressure to atmosphere	250 psig
Low suction pressure cutout	Protect the compressor from damage due to low suction pressure by shutting down compressor	10 psig
High discharge pressure pre-alarm and cutout	Alert personnel and protect the compressor from damage due to high discharge pressure by alarming and then shutting down compressor	200 psig pre-alarm 225 psig cutout
Low lubrication oil pressure cutout	Protect the compressor from damage due to low lubrication oil pressure by shutting down compressor	20 psig

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Low lubrication oil temperature cutout	Protect the compressor from damage due to low lubrication oil temperature by shutting down compressor	70°F
High lubrication oil temperature cutout	Protect the compressor from damage due to high lubrication oil temperature by shutting down compressor	160°F
High discharge temperature cutout	Protect the compressor from damage due to high discharge temperature by shutting down compressor	200°F
Ammonia detector in ammonia machinery room	The detector will provide audible and visual alarms in the machinery room, send an alarm to control room, and start the machinery room ventilation system if the setpoint is reached.	35 ppm
Emergency stop button	When the emergency stop button located at the entrance to the machinery room is hit: • The ammonia compressors will stop. • The ammonia pumps will stop. • The solenoid valves in the liquid fill lines to machinery room vessels will close.	N/A

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