IIAR Standards and Guidelines for Ammonia and CO_2 Refrigeration

M-A2

March 24, 2025

Eric M. Smith, PE – Vice President and Technical Director, IIAR

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27th California Unified Program
Annual Training Conference
March 24-27, 2025

Our Vision

To create a better world through the safe and sustainable use of natural refrigerants

standards,
education,
advocacy

Who are we?

Membership based technical society with broad Industry representation who

Promotes the safe and sustainable use of Natural Refrigerants

- Started in 1971 due to controversial NEC regulation
- ANSI accredited standards developer
- Publish Technical Resources
- Provide Education
- Advocate for Natural Refrigerants

Who are we?

Member-based Technical Society

Our members represent diverse areas of the refrigeration Industry

3,700+ Members including:

- Designers
- Manufacturers
- Contractors
- End users
- Scientists
- Academics
- Students
- Consultants
- Government Personnel

Allied Organizations

CALIFORNIA CUPA FORUM

27th California Unified Program
Annual Training Conference
March 24-27, 2025

Annual Conference

- 40 Technical Sessions
- Exhibit
- Committee Meetings
- Social Networking

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March 24-27, 2025

CALIFORNIA CUPA FORUM

NATURAL REFRIGERATION FOUNDATION

Our Mission

To Promote the safe and sustainable use of natural refrigerants through Research and Scholarships

education

research

SAFE AND SUSTAINABLE USE OF NATURAL REFRIGERANTS

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A Brief Review of Refrigeration

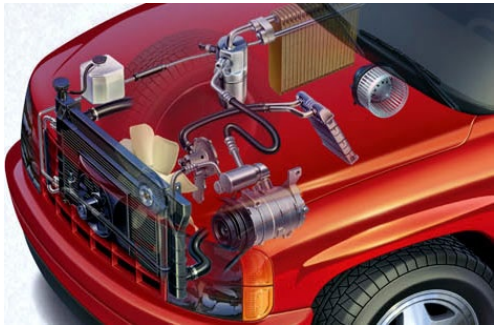
The concept of refrigeration went unchanged for

2000+ years until mechanical refrigeration was invented

150+

years ago

A Brief Review of Refrigeration



These Days, Refrigeration is Everywhere!

A Brief Review of Refrigeration

Mechanical Refrigeration

Since its invention, the process of mechanical refrigeration has remained relatively unchanged

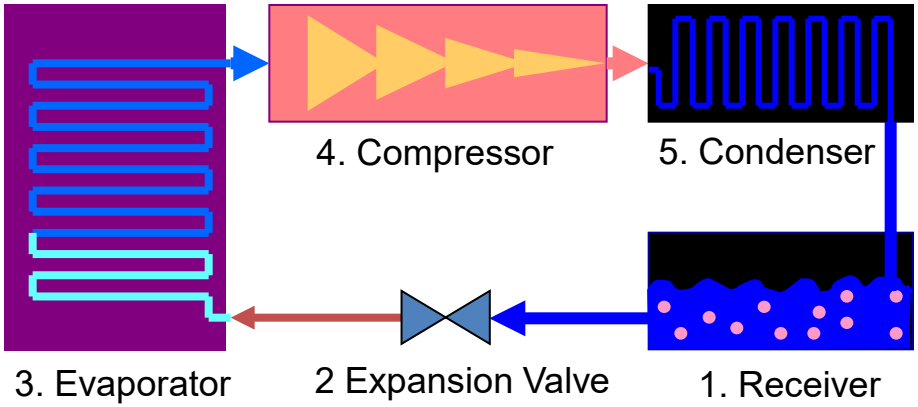
A Brief Review of Refrigeration

Refrigeration systems do not add cold…they remove and relocate heat

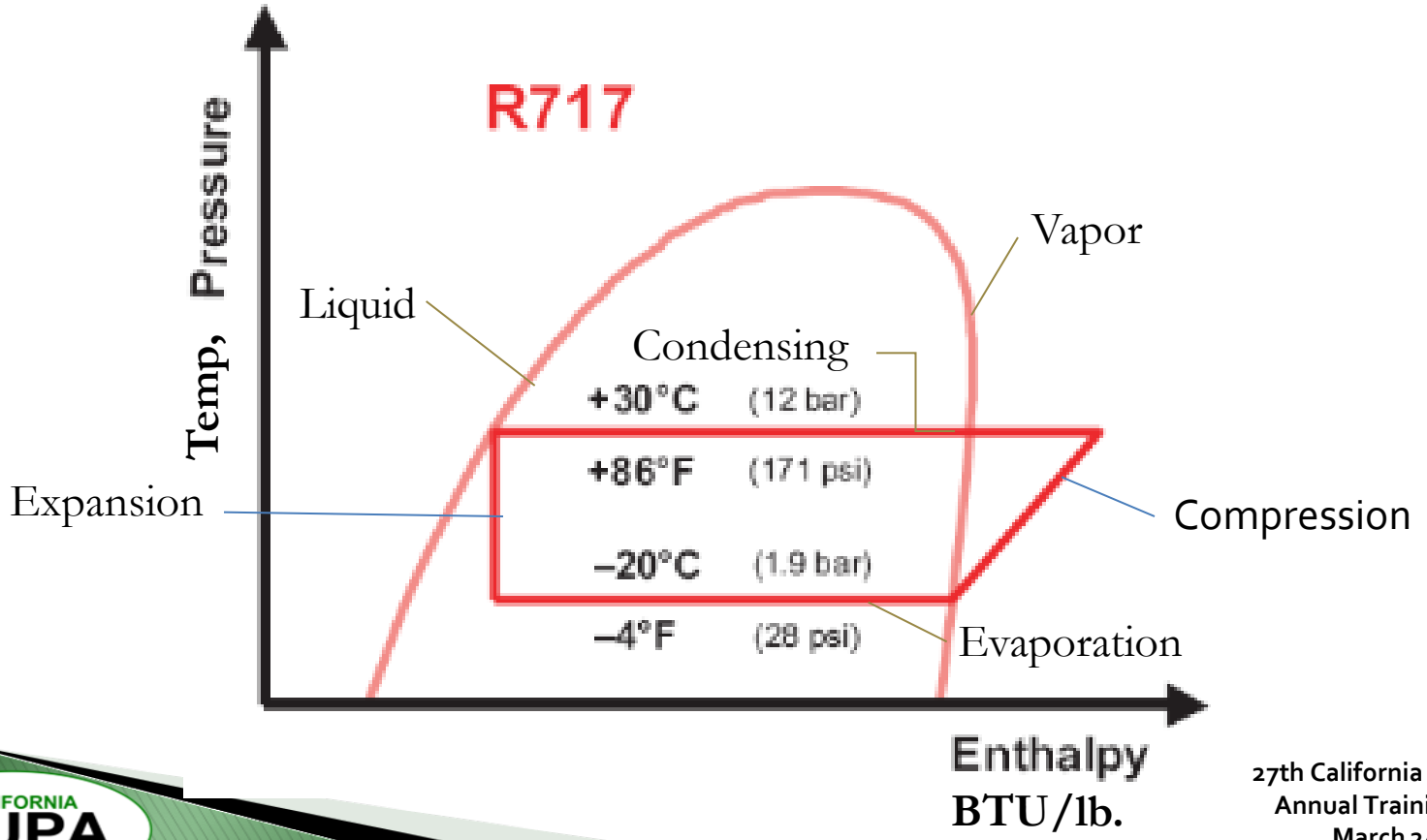
- Think of a train on a circular track with two stations.
  - "Heat passengers" are loaded at one station and unloaded at the other

A Brief Review of Refrigeration

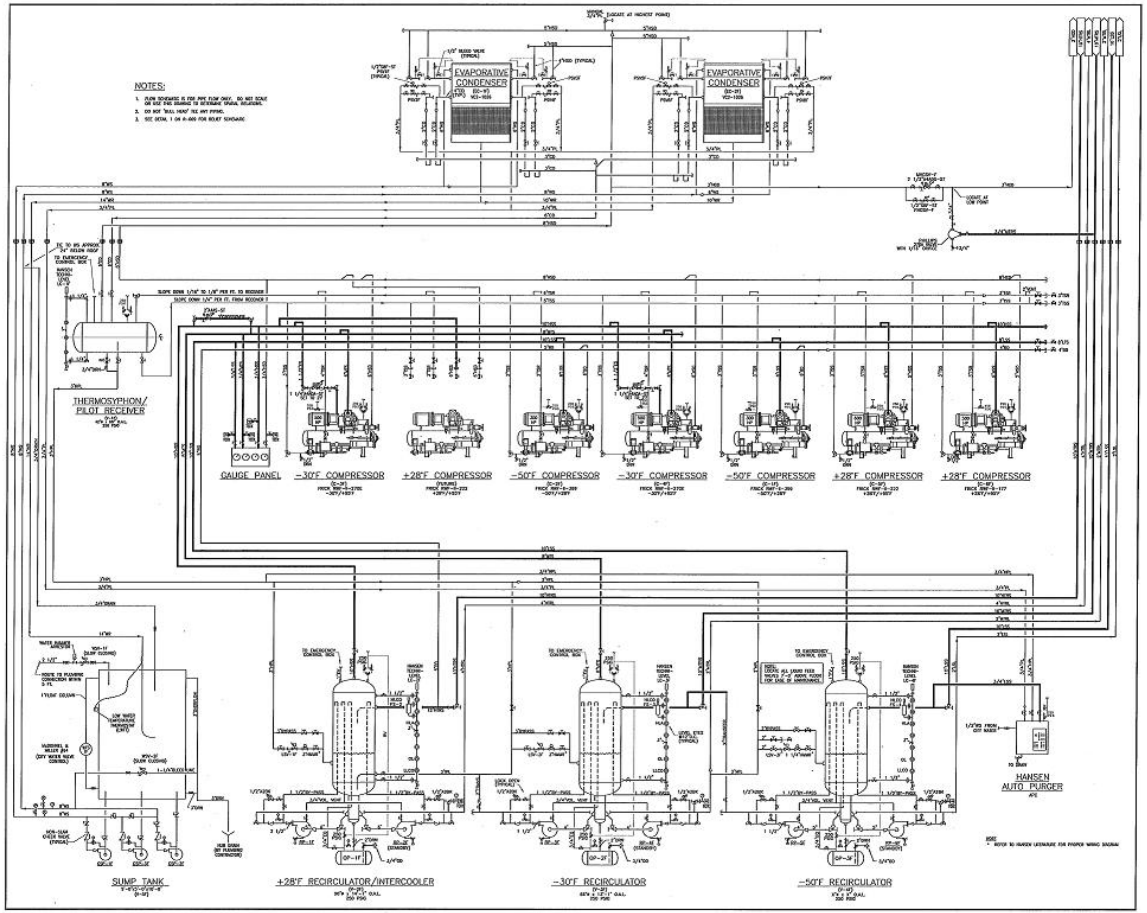
Refrigeration Systems
-How they work-



Thermodynamics – A Crash Course

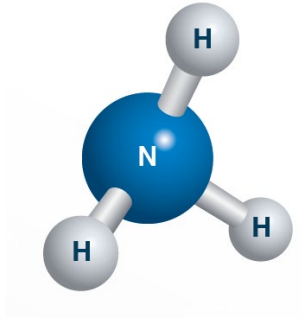


Industrial Scale Systems:


NOTES:
EVAPORATIVE CONDENSER
EVAPORATIVE CONDENSER
THERMOSYPHON/ PILOT RECEIVER
GAUGE PANEL
−30°F COMPRESSOR
+28°F COMPRESSOR
−50°F COMPRESSOR
−30°F COMPRESSOR
−50°F COMPRESSOR
+28°F COMPRESSOR
+28°F COMPRESSOR
HANSEN AUTO PURGER
SUMP TANK
+28°F RECIRCULATOR/INTERCOOLER
−30°F RECIRCULATOR
−50°F RECIRCULATOR

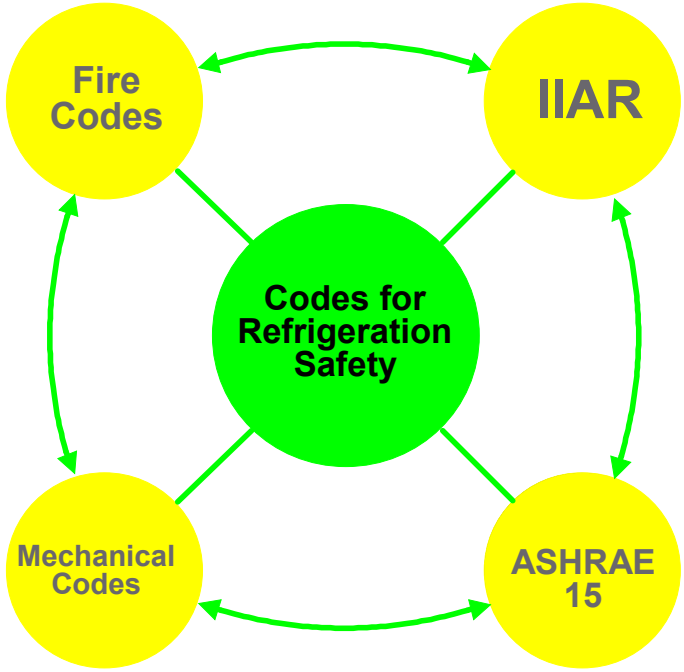
Why AMMONIA as a Refrigerant?

- Energy Efficient
- Inexpensive, worldwide availability
- Single molecule
- Excellent Thermodynamic Properties & low pressure
- Non-miscible with oil – energy efficient, easy to manage
- Environmentally Friendly



Ammonia STINKS !

Codes and Standards Regulating Ammonia Refrigeration Systems



CalEPA
California Environmental Protection Agency

OSHA

Back to What we do:

Standards, Education, Advocacy

- We write and establish Standards for use in the industry
- We publish guidelines for safety, longevity and efficiency of refrigeration systems with natural refrigerants
- We produce Educational Material for the benefit of the refrigeration industry with natural refrigerants
- We advocate for the safe use of Natural Refrigerants

Standards

Education

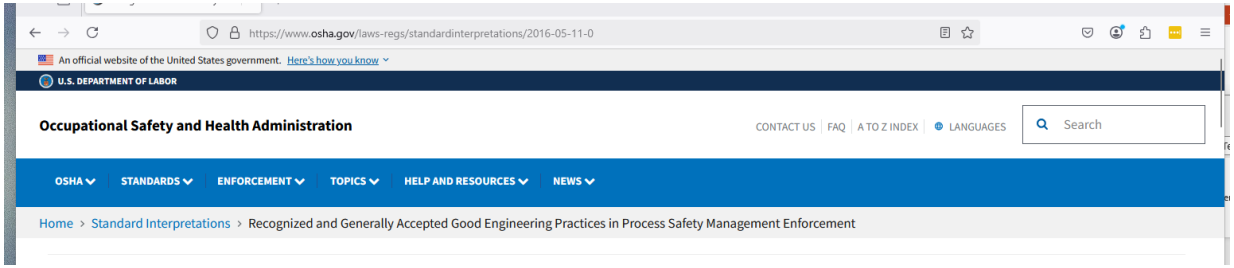
Advocacy

IIAR Suite of Standards

IIAR

"Accredited ANSI Standards Developer"

Standards Developer Organization (SDO)



Examples of RAGAGEP

1. **Widely adopted codes**
   Certain consensus standards have been widely adopted by federal, state, or municipal jurisdictions. For example, many state and municipal building and other codes incorporate or adopt codes such as the National Fire Protection Association (NFPA) 101 *Life Safety* and NFPA 70 *National Electric* codes.

2. **Consensus documents**
   Certain organizations like the American Society of Mechanical Engineers (ASME) follow the American National Standards Institute's (ANSI) *Essential Requirements: Due process requirements for American National Standards* (Essential Requirements) when developing consensus standards and recommended practices. Under the ANSI and similar requirements, these organizations must demonstrate that they have diverse and broadly representative committee memberships. Examples of consensus documents include the ASME B31.3 *Process Piping Code* and the International Institute of Ammonia Refrigeration's (IIAR) ANSI/IIAR 2-2008 — *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems.* Such consensus documents are widely used as sources of RAGAGEP by those knowledgeable in the industry.

3. **Non-consensus documents**
   Some industries develop non-consensus engineering documents using processes not conforming to ANSI's Essential Requirements. Where applicable, the practices described in these documents can be widely accepted as good practices. For example, the Chlorine Institute's (CI) "pamphlets" focus on chlorine and sodium hypochlorite (bleach) safety and are used by some companies handling these materials. Note that OSHA also recognizes applicable manufacturer's recommendations as potential sources of RAGAGEP.

4. **Internal standards**
   The preamble to the PSM standard recognizes that employers may develop internal standards for use within their facilities. The preamble states, in relevant part:

   1. The phrase suggested by rulemaking participants: "recognized and generally accepted good engineering practices" is consistent with OSHA's intent. The Agency also believes that this phrase would include appropriate internal standards of a facility . . . .[(1)]

IIAR Suite of Standards

for Closed-Circuit Ammonia Refrigeration Systems

IIAR 1 – 2022	Definitions and Terminology Used in IIAR Standards
IIAR 2 – 2021	Safe Design
IIAR 3 – 2022	Ammonia Refrigeration Valves
IIAR 4 – 2020	Installation
IIAR 5 – 2019	Start-up
IIAR 6 – 2019	Inspection, Testing, and Maintenance
IIAR 7 – 2019	Developing Operating Procedures
IIAR 8 – 2020	Decommissioning
IIAR 9 – 2024 (Addendum A)	Minimum System Safety Requirements for Existing Systems

And Just So You Know:

BSR/IIAR HC-202x

In Development

Safety Standard for Closed-Circuit Refrigeration Systems Utilizing Hydrocarbon Refrigerant

ANSI approved 2021, adopted by Code 2024

Industry Codes:

- ✓ International codes and industry standards such as IMC, IFC, UMC, NFPA-1 Fire Code, require the use of ANSI / IIAR standards as the basis of regulation for Ammonia Refrigeration! ASHRAE 15 includes a reference to IIAR standards for ammonia refrigeration design.

2024 IFC
IIAR 2, 6, 7, 8, 9, CO_2

2024 IMC
IIAR 2, 3, 4, 5, 6 and CO_2

2024 NFPA 1 Fire Code
IIAR 2, 6, 7, 8

2023 NFPA 70 NEC
IIAR 2

2024 UMC
IIAR 2, 3, 4, 5, 6, and CO_2

History of IIAR 2

First published in 1974 as the *IIAR Standard for Equipment, Design and Installation of Ammonia Mechanical Refrigeration Systems*

Subsequent revisions and addendums:

ANSI/IIAR 2 - 1978 – *Equipment, Design, and Installation of Ammonia Mechanical Refrigeration Systems*

ANSI/IIAR 2 - 1984

ANSI/IIAR 2 - 1992

ANSI/IIAR 2 - 1999

2005 – ANSI/IIAR 2 - 1999, Addendum A - *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*

ANSI/IIAR 2 – 2008

2010 - ANSI/IIAR 2-2008, Addendum A

2012 – ANSI/IIAR 2-2008, Addendum B

2014 – ANSI/IIAR 2-2014 (major change) *Safe Design of Closed-Circuit Ammonia Refrigeration Systems*

2019 – ANSI/IIAR 2-2014, Addendum A (absorption systems added, clarifications)

2021 – ANSI/IIAR 2-2021 *Design of Safe of Closed-Circuit Ammonia Refrigeration Systems*

202X – BSR/IIAR 2-202x - - Underway

IIAR 2-2021

- Parts 1-3 contain normative material.
- Introductory sections and Part 4 (Appendices) contain informative material.
- Appendix A contains explanatory information for specific normative sections marked with an asterisk.
- Many terms are defined and can be found in IIAR 1 or IIAR 2, Chapter 3.

1.1 Purpose:

- This standard specifies the minimum requirements for the design of safe closed-circuit ammonia refrigeration systems.
- Safety focus is on persons and property located at or near the premises where the refrigeration systems are located.
- This standard is not intended to serve as a comprehensive technical design manual.
- Use of this Standard is voluntary unless its use is mandated by the Authority Having Jurisdiction (AHJ).

1.2 Scope - Exclusions

- Replacement in-kind.
- Equipment and systems and the buildings or facilities in which they are installed that existed prior to the legal effective date of this standard. Such equipment, systems, buildings, and facilities shall remain in accordance with the codes and standards that applied at the time of installation and in accordance with IIAR 9.

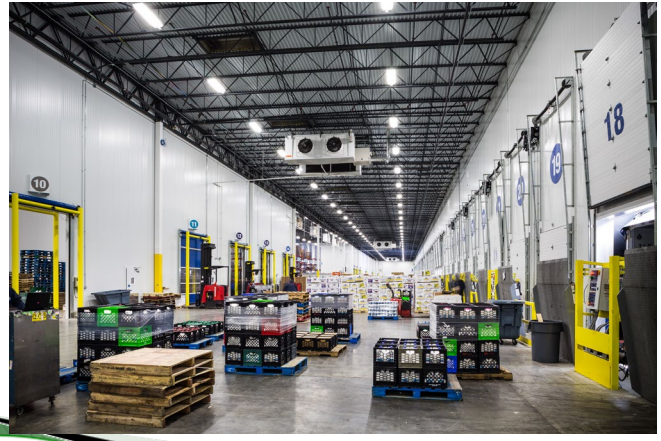
Definitions: Some important ones

Equipment Enclosure: An enclosure designed to house refrigeration equipment or devices associated with a closed-circuit refrigeration system, or both, that is not intended for occupancy.

- Often not a walk-in structure. Access usually through removable panels or doors.

Definitions: Some important ones

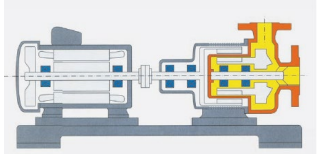
Industrial Occupancy: A premises or a portion thereof that is not open to the public, where access is controlled such that only *authorized personnel* are admitted and that is used to manufacture, process, or store goods.

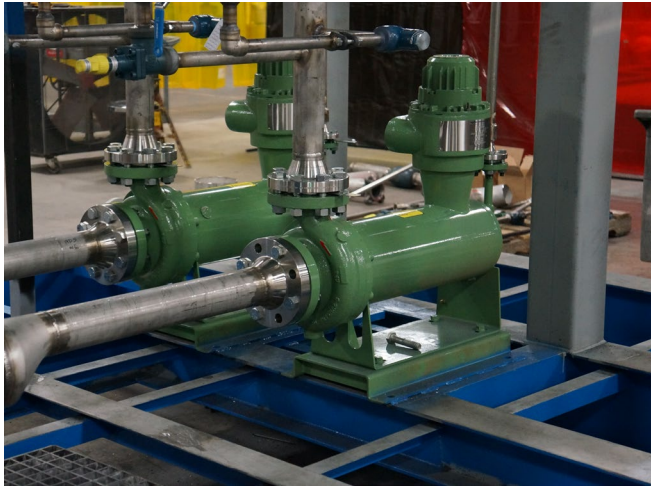


Definitions: Some important ones

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

- Developed to describe a pump that could be used in an area other than a machinery room.



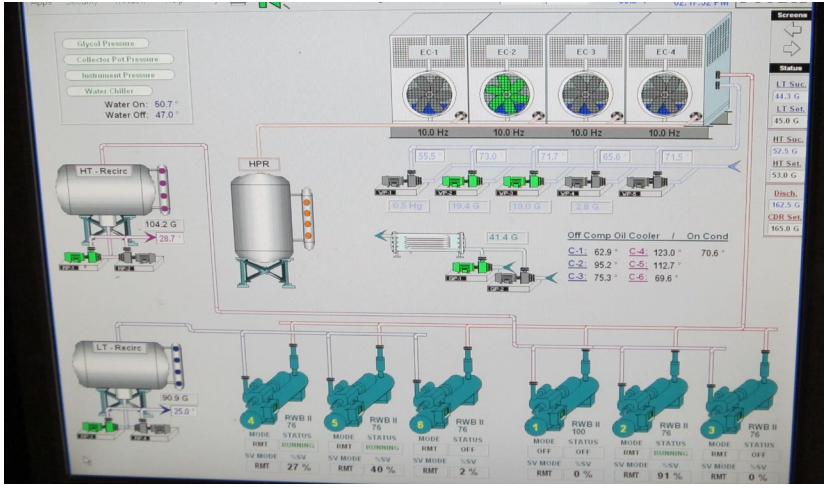


Definitions: Some important ones

Machinery Room: An enclosed space that is designed specifically to safely house refrigeration *equipment* and complies with the requirements set forth in Chapters 4 and 6 of IIAR 2.

Definitions: Some important ones

Monitored: A means of continuous oversight, such as notification of on-site staff, a third-party alarm service, or a responsible party.



- This is an important element in system design as it is a vital part of unstaffed systems.

Definitions: Some important ones

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

Note this definition includes all components in the definition, not just pipe.

Definitions: Some important ones

Penthouse: A structure used to house ammonia refrigeration equipment that is adjacent to a larger room.

- Penthouses open to an interior space shall be regulated as part of the interior space.
- Penthouses that are isolated or can be automatically isolated from an interior space are regulated as equipment enclosures.

Definitions: Some important ones

Regularly Patrolled: A documented frequency of inspection as determined using a process hazard analysis and/or hazard review.

Some Important Referenced Standards:

- Machine Guarding

IIAR 2 refers to ASME for requirements for:

- Pressure Vessels: Boiler & Pressure Vessel Code (B&PVC) (2021)
- Pipe Flanges and Fittings: B16.5 (2020) and B16.11 (2016)
- Gaskets: B16.20 (2017) and B16.21 (2016)
- Piping and Heat Transfer Components: B31.5 (2019)
- See section 12.2 of IIAR 2 for qualifications regarding B&PVC.
- See section 13.2 of IIAR 2 for qualifications regarding B31.5.

- IIAR 2 refers to ASTM for pipe specification requirements.

- IIAR 2 refers to ISEA for the requirements for the design, certification, performance, installation, use, and maintenance of emergency showers and eyewashes. Installation location and alternatives by IIAR 2.

- National Electric Code
- Signaling
- Standard 704 for warning signs

Locations for Ammonia Equipment

Ammonia refrigeration machinery shall be located in a machinery room complying with Chapter 6, **UNLESS…**

- Listed equipment with limited charge.
- Outdoor installations.
- Industrial occupancies.
- Public assembly, commercial, and large mercantile occupancies, with certain restrictions.

Industrial Occupancies

- Heat exchangers (and associated surge drums) used for space cooling or heating and process heating or cooling.
- Low-probability pumps.
- Valves and connecting piping associated with the above items.
- An ammonia refrigeration system with a total connected compressor drive power not exceeding 100 HP.

Secondary Coolants

- Ammonia refrigeration equipment is permitted to be used in conjunction with a secondary coolant that serves any occupancy provided that the system is indirect.

System Design Pressure Design Considerations

- Allowance for pressure limiting and pressure relief devices – avoid shutdowns or releases.
- Equipment and piping connected to a pressure vessel – equal to or greater than the relief setpoint for the pressure vessel.
- Compressors used as boosters – part of low pressure side.
- Connecting to existing low pressure equipment – new equipment to be per new standard; used equipment permitted to equal that of the existing.

Purging

- The design requirement provides a means to remove air and other noncondensables from the system.

Oil Management

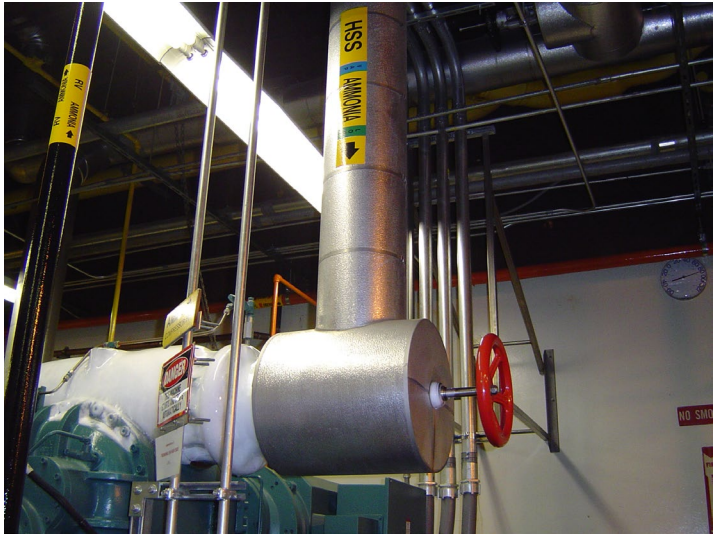
- The design shall include provisions for removing oil from piping and equipment.
- Where required by the manufacturer's recommendations, compressor packages shall have a means to sample oil for periodic analysis.

Oil Removal Systems

Must be one or more of the following:

- A rigid piped oil return or transfer system.
- A vessel equipped with a shutoff valve in series with a self closing shutoff valve.
- A valve and piping assembly at the oil accumulation point which as a minimum requires a shutoff valve in series with a self closing valve.

Condensation and Frost Control



- Piping and equipment not intended for heat exchange shall be protected to mitigate condensation and frost buildup where these could lead to corrosion or become a hazard to occupants or cause damage to the structure, electrical equipment, or any component of the refrigeration system.
- The primary means of protection is insulation but other means such as the use of corrosion-resistant materials, surface treatments, and routine defrosting are permitted.
- Valve groups and other equipment are permitted to be uninsulated for service.

Supports and Foundations

- Shall be included in the design of the ammonia refrigeration system.
- Shall be designed in accordance with the Building Code and the Manufacturer's Recommendations.
- Shall be non-combustible except under piping supports on the roof for roof protection.
- Shall prevent excessive vibration or movement of piping or equipment.
- Designer shall provide documentation defining the basis of the support design.

Access to Valves

- Manually operated isolation valves identified in emergency shutdown procedures must be operable from the floor, by chain, or a remote-actuated operator, that is operated from a permanent work surface. These valves must have enough clearance to operate them while wearing emergency response protective equipment.
- Emergency valves must be identified at the valve itself.

Signage, Labels and Pipe Marking

- Machinery room signage – in section 6.15, will be reviewed in Module 3.
- Refrigeration equipment shall be provided with identification labels.
- NFPA 704 Placards are Required

Emergency Shutdown Documentation

- The owner is responsible to provide directions for the emergency shutdown of the system.
- The requirement for establishing emergency shutdown procedures is given in IIAR 7.
- Signage or Schematic drawings posted at a readily accessible location
- Must include details and steps for shutting down the system in an emergency
- Must include current emergency contact information

Machinery Rooms

- Most often a requirement
- Tight Construction
- Proper Access and Egress – Restricted Access
- Open Flames & Hot Surfaces – only under certain conditions
- Eyewash/Safety Showers – inside and outside of the Room – some exceptions for small rooms
- Usually not "Classified" if Emergency Ventilation is provided
- Temperature Control and Emergency Ventilation
- Ammonia Detection and a series of actions
- Alarms inside and outside
- Signage – Alarms, access, NFPA 704

Machinery Rooms

- Lighting and Ventilation for Occupants
- Fire Rated by Building Code – usually 1 hour with sprinklers….sometimes wooden!
- Emergency Ventilation and Shutdown controls
- Starters and Other Building Equipment is usually ok.

When is it a Machinery Room?

- When it is required by Chapter 4
- When it has Compressors and Vessels (used for distribution)

Areas other than Machinery Rooms

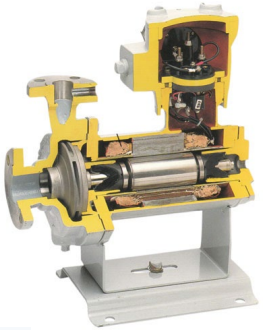
When permitted by Chapter 4:

- Production and Cold Storage Rooms, docks etc.
- Tight Separation from Other Occupancies--- does not mean there can't be open passages within…e.g. conveyor passages etc.
- Equipment Protected from Fork Truck damage
- Compatible with the environment
- Ammonia detection almost always required
- Eyewash and SS not required, unless system is to be opened.
- Penthouses treated like the rooms they serve
- Outdoor installations are also areas other than a machinery room
- Equipment Pits – Special Provisions
- Small Refrigeration Packages Permitted with special provisions.

The Equipment Chapters

Chapters 8,9,10,11

- Compressors, Pumps, Condensers, Evaporators
- Design and testing requirements
- Protection features
- Special pressure relief for Compressors
- ASME design for Some Heat Exchangers
- Protection against automatic isolation



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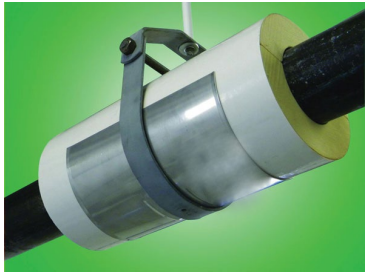
The Equipment Chapters

Chapters 12 – Pressure Vessels

- ASME Design for most – 6" and smaller not ASME
- Testing per ASME
- Some special requirements for small nipples
- Nameplate requirements – dual plating is ok
- Dual Operating Temperatures ok if approved and stamped

Piping

- Carbon or Stainless Steel – sometimes aluminum
- ASTM A53 or A333….Type F not allowed
- No Copper!
- Welding Certificates Required
- Suction piping to be sloped to vessels
- All threaded piping must be Schedule 80 (IIAR requirement)
- Carbon Steel 1.5" or smaller shall be Schedule 80
- Stainless Steel 1.5" or smaller shall be Schedule 40
- Limitations on carbon steel Tubing
- Corrugated Tubing allowed
- Valves are Piping
- All piping shall be connected or capped
- Piping supports – only ASME supports are permitted – No haphazard supports!
- Piping shall be isolated and supported



Packaged Systems

- Usually Outdoors, roof or ground mounted
- Generally must comply with the rest of the standard
- Some exceptions for Ventilation and Eyewash/SS
- Many use natural ventilation (minimum free area)
- Detection sometimes required
- Structural Design for Shipping

Overpressure Protection

- Numerous Rules to Follow
- Calculations are Required and must be documented
- Different Calculations for different types of Equipment
- Relief Valves and Piping are the "last defense".
- Liquid and Vapor Relief are Treated a bit differently
- Relief back into the system is ok, but at least one relief to atmosphere
- Hydrostatic Protection also Required…various methods including use of administrative controls when doing maintenance.
- Rarely have there been problems…only when an RV is blocked.
- Authority Having Jurisdiction (AHJ) might require Emergency Pressure Control and/or dilution tanks

Relief Discharge Piping

- Numerous Rules to Follow
- Backpressure Calculations Required
- Minimum 15’ above Grade
- Minimum 7.5’ above work platforms (e.g. condenser catwalks)
- Horizontal distance to adjacent walls must be considered
- 20’ from building openings
- Outlet must be directed upward – goosenecks are old thinking
- Protect Outlets from Weather
- Only ammonia vapor in vapor discharge

Instrumentation and Controls

- Instruments and controls shall be provided:
  - To indicate the operating parameters of the refrigeration system and equipment.
  - To manually or automatically control the starting, stopping, and operation of the system and equipment.
  - To give notice when the systems critical operating parameters have been exceeded.
- The function, sequence, and operating design parameters shall be documented and maintained in a location that is accessible at the site.
- A means shall be provided for monitoring the concentration of an ammonia release in the event of a power failure.

Instrumentation and Controls

- Changing of safety settings shall be limited to authorized personnel.
- Changing of operational settings shall not affect the safety settings.
- Electrical control systems shall comply with the Electrical Code.
- Instruments with pressure containing envelopes shall have a maximum allowable working pressure equal to or greater than the design pressure of the system in which they are installed.

Ammonia Detection and Alarms

Ammonia detectors and alarms:

- Located in machinery rooms shall comply with Sections 17.2 through 17.6 of this chapter and Section 6.13.
- Located in areas other than machinery rooms shall comply with this chapter and Sections 7.2.3 and 7.3.1.2.3.
- For packaged systems & equipment shall comply with this chapter and Section 14.4.
- Ammonia detectors shall be designed and tested per UL 61010-1 or ANSI/ISA 92.00.01.

Ammonia Detection and Alarms

- In an emergency shut down and during maintenance, ammonia detection and alarm systems must remain on. If there is a loss of power to the alarm and/or detection system, a signal to be sent to a monitored location.

- Detectors shall have supervised wire runs that alert any faults in the wiring.
- Loss of communication between the detector and the control system shall be reported to a monitored location.
- Detectors shall actively monitor the primary sensing element and report trouble to a monitored location.

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- Loss of communication between the detector and the control system shall be reported to a monitored location.
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Ammonia Detector Placement

- A leak detection sensor or sampling tube shall be mounted in a position where it is expected to be the most effective.
- Leak detection sensors shall be mounted in a position where they can be accessed for maintenance and testing.

Alarm Sound Level and Signage

Must be loud enough to be heard over ambient noise

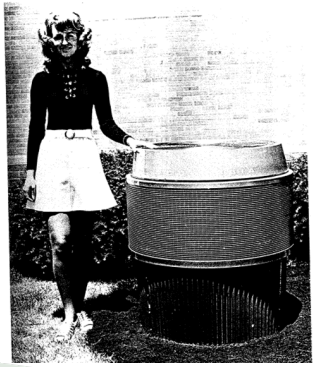
Visual and Audible alarms shall be identified with signage

Ammonia Based Absorption Systems – in Brief

18 kW Heating

5 RT Chiller

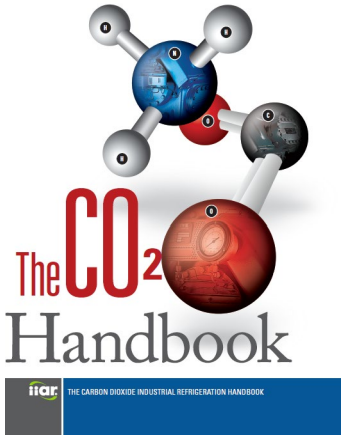
A large industrial application

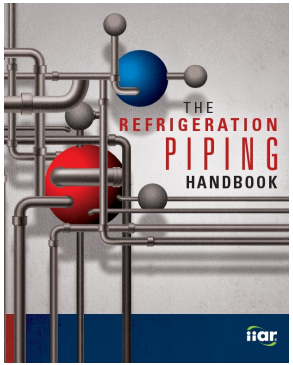


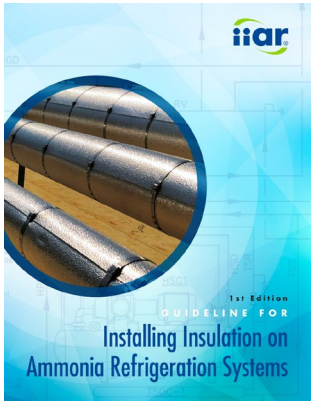
A residential system from the 1960's

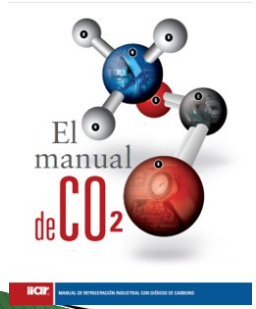
- **Applications Drive Requirements**
  - Larger absorption systems must comply with nearly all requirements of IIAR 2, except as noted in chapter 18.
  - Smaller systems are usually packaged and contain less than 22 lbs. of ammonia. Chapter 18 provides exceptions for such equipment.

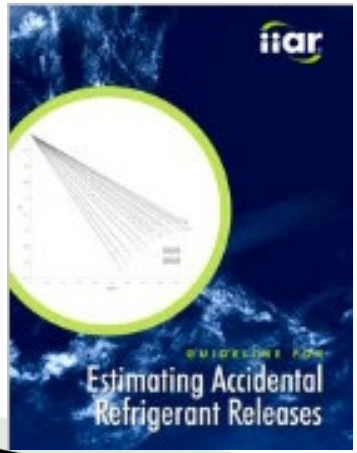
Other Publications











Other Publications Not Shown:

- PSM/RMP Guidelines
- Ammonia Refrigeration Management (for General Duty)
- Lockout/Tagout Guideline
- Entry for Evaporative Condensers
- Low Charge Management Program (for General Duty)
- Ammonia Data Book
- Critical Tasks for Emergency Planning

Certificate courses

- ANSI/IIAR 2 **Available in Spanish*
- ANSI/IIAR 4 **Available in Spanish*
- ANSI/IIAR 6 *Available in Spanish
- ANSI/IIAR 7 *Available in Spanish
- ANSI/IIAR 9 **Available in Spanish*
- Estimating Accidental Refrigerant Releases
- Process Safety Management & Risk Management Program Guidelines
- Planning and Performing an Effective Process Hazard Analysis
- Ammonia Refrigeration Management (ARM) Program

ACADEMY OF NATURAL REFRIGERANTS

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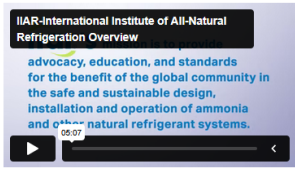
Government Services Support Portal

The mission of the International Institute of All-Natural Refrigeration (IIAR) is to provide advocacy, education, and standards for the benefit of the global community in the safe and sustainable design, installation and operation of ammonia and other natural refrigerant systems. Governmental officials including inspectors, code officials, emergency planners and responders are provided free access to the information on this IIAR Government portal which includes industry standards, technical resources, and training materials to provide an understanding of refrigeration system design standards, best practices for operations and maintenance, and refrigerant safety data. Preparedness for emergency response works best when government, public safety, and industry representatives work as a team, using a tripod approach that requires all three entities to engage in a dialogue. This drastically reduces the chance of incidents and helps to ensure smooth management of incidents should they occur by keeping them small. The IIAR serves as a technical resource and is available for questions and answers to provide government and first responder personnel with needed insights to the standards. This allows for enforcement of recognized and generally accepted good engineering practices in a manner that benefits all parties.



Request Access

United States Government Regulatory Agencies

OSHA - Occupation Safety and Health Administration

EPA - Environmental Protection Agency

DHS - Department of Homeland Security

AIM Act - Information on EPA website

Note: The Government Portal and First Responder Portal have been combined into the Government Services Portal.

- IIAR Standards
- IIAR Bulletins
- IIAR Training Materials
- Ammonia Health and Safety Data
- Technical Resources
- Technical Questions
- Community Coordination
- First Aid for Ammonia

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$100 per Individual - IIAR approval is required.

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Affiliate: Code Groups, Insurance Companies/Agencies, Government & Regulatory Agencies, Active Military
Retired: A person no longer gainfully employed in the industry on a full-time basis
Student: A person currently enrolled full-time in a university, technical college or trade school and by virtue of their educational endeavors is interested in a career within the industry providing and supporting refrigeration systems for cooling, freezing, and heating using natural refrigerants. A copy of your student ID and transcript should be sent to membership@iiar.org.

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