RESOURCE COMPLIANCE

Ammonia Refrigeration Codes and Standards

Peter Thomas, P.E. | President and Engineer | Resource Compliance

Codes and Standards

Mechanical Integrity / Maintenance

Process Safety Information / Safety Information

Design Codes and Standards / RAGAGEP

Process Safety Information

§2755.1(a)(5) Safety Information

- The owner or operator shall compile and maintain the following up-to-date safety information related to the regulated substances, processes, and equipment:

5. Codes and standards used to design, build, and operate the process.

§2760.1(d)(1)(F) Process Safety Information

- Information pertaining to the equipment in the process shall include:

(F) Design codes and standards employed;

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§2755.1(b) Safety Information

- The owner or operator shall ensure that the process is designed in compliance with recognized and generally accepted good engineering practices.

§2755.5(d) Maintenance

- Inspection and testing procedures shall follow recognized and generally accepted good engineering practices. The frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations, industry standards or codes, good engineering practices, and prior operating experience.

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§2760.1(d)(2) Process Safety Information

- The owner or operator shall document that equipment complies with recognized and generally accepted good engineering practices.

§2760.5(d)(2) Mechanical Integrity

- Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

§2760.5(d)(3) Mechanical Integrity

- The frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience.

Ammonia Refrigeration Code Organizations

iiar International Institute of Ammonia Refrigeration

ANSI

ICC INTERNATIONAL CODE COUNCIL®

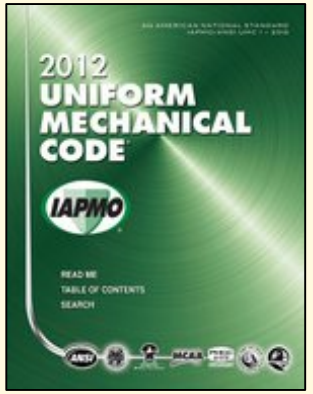
IAPMO

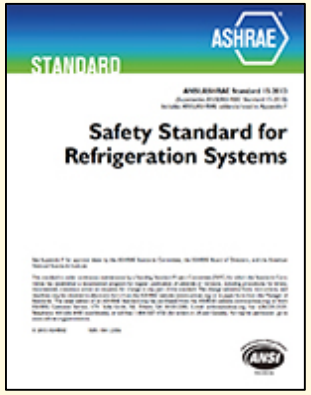
ASME SETTING THE STANDARD

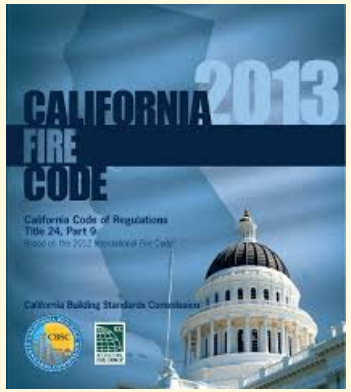
ASHRAE

Ammonia Refrigeration Code Documents

- IIAR Standards
- International Mechanical Code (IMC)
- Uniform Mechanical Code (UMC)
- International Fire Code (IFC)
- Fire Code (NFPA 1)
- ANSI/ASHRAE 15 Safety Standard for Refrigeration Systems







IIAR Standard 2

Sponsor

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION

Approved by
The American National Standards Institute
March 16, 1978

AMERICAN NATIONAL STANDARD
FOR

EQUIPMENT, DESIGN, AND INSTALLATION OF AMMONIA MECHANICAL REFRIGERATION SYSTEMS

ANSI/IIAR 74-2 · 1978

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Approved by
The American National Standards Institute
March 16, 1978

IIAR Standard 2

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AMERICAN NATIONAL STANDARD

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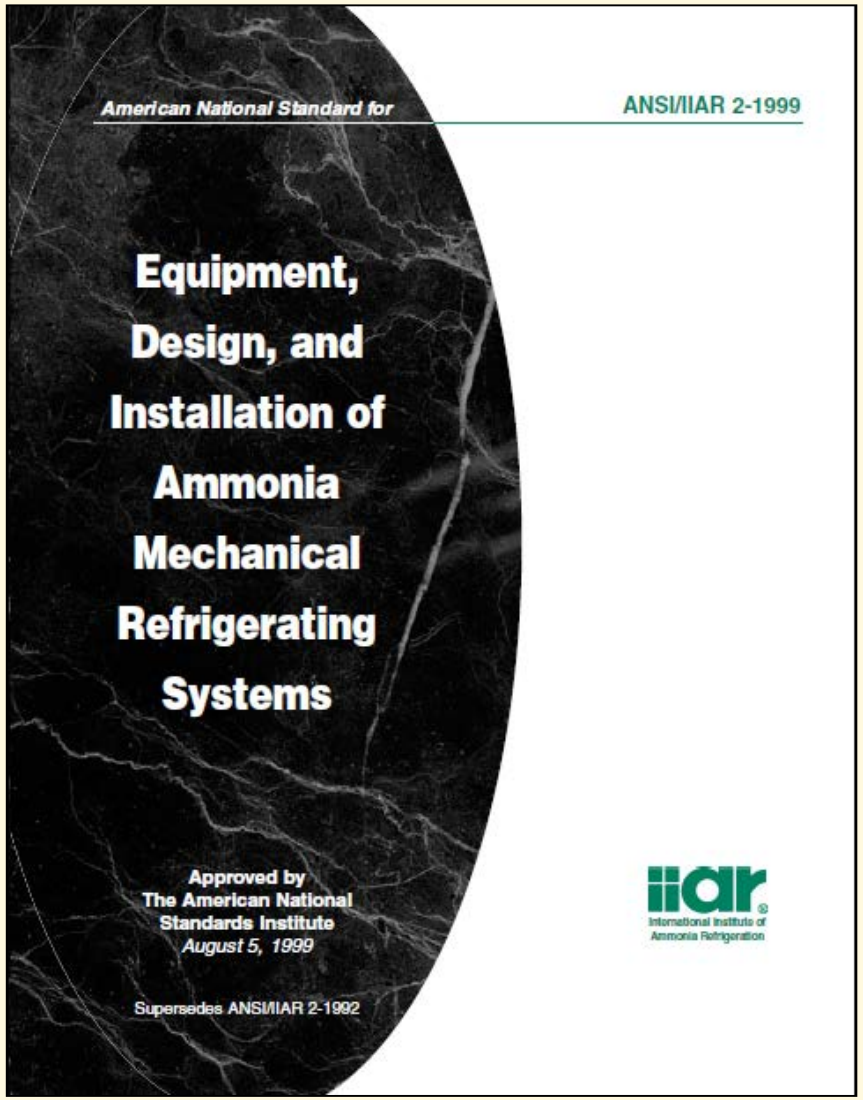
IIAR Standard 2


American National Standard for

ANSI/IIAR 2-1999

Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems

Approved by
The American National Standards Institute
August 5, 1999

Supersedes ANSI/IIAR 2-1992

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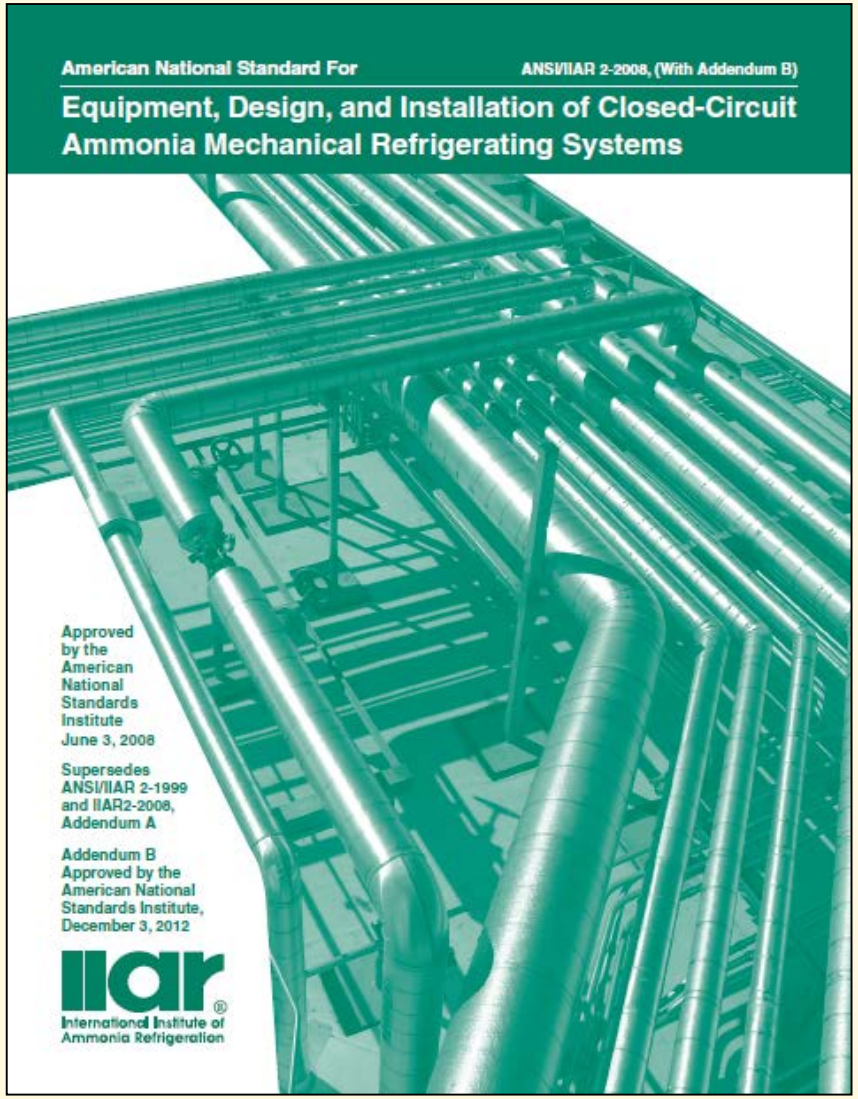
International Institute of Ammonia Refrigeration

IIAR Standard 2

Approved by the American National Standards Institute June 3, 2008

Supersedes ANSI/IIAR 2-1999 and IIAR2-2008, Addendum A

Addendum B Approved by the American National Standards Institute, December 3, 2012

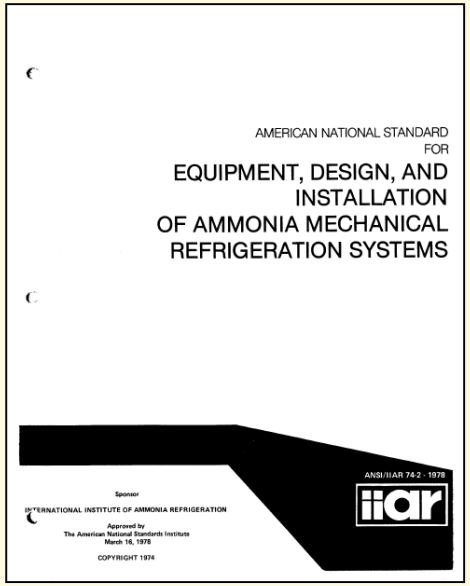


IIAR Standard 2

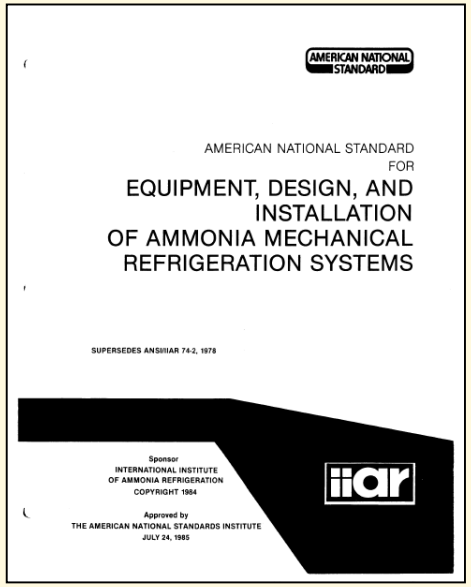
IIAR Standard 2

- ANSI/IIAR 2 Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems

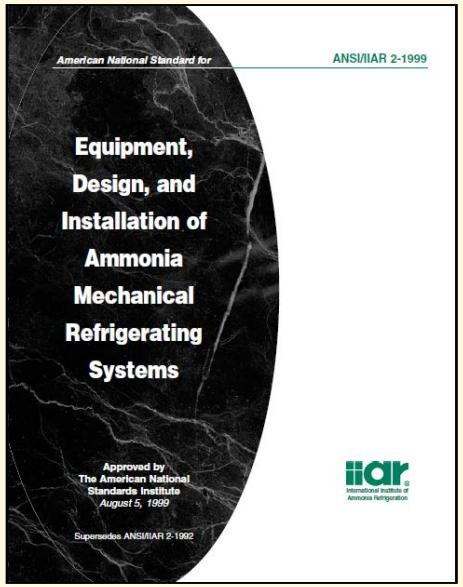
1974-78



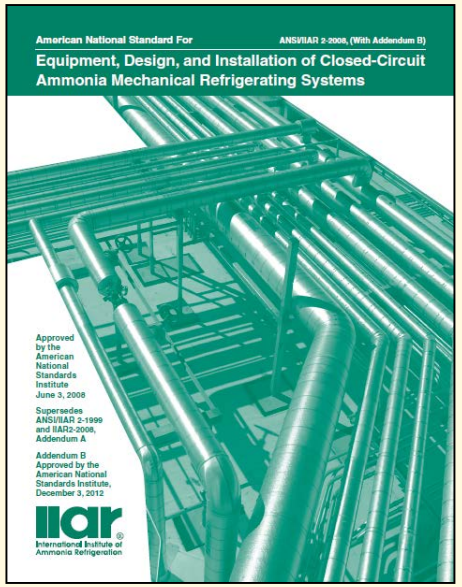
1984



1999

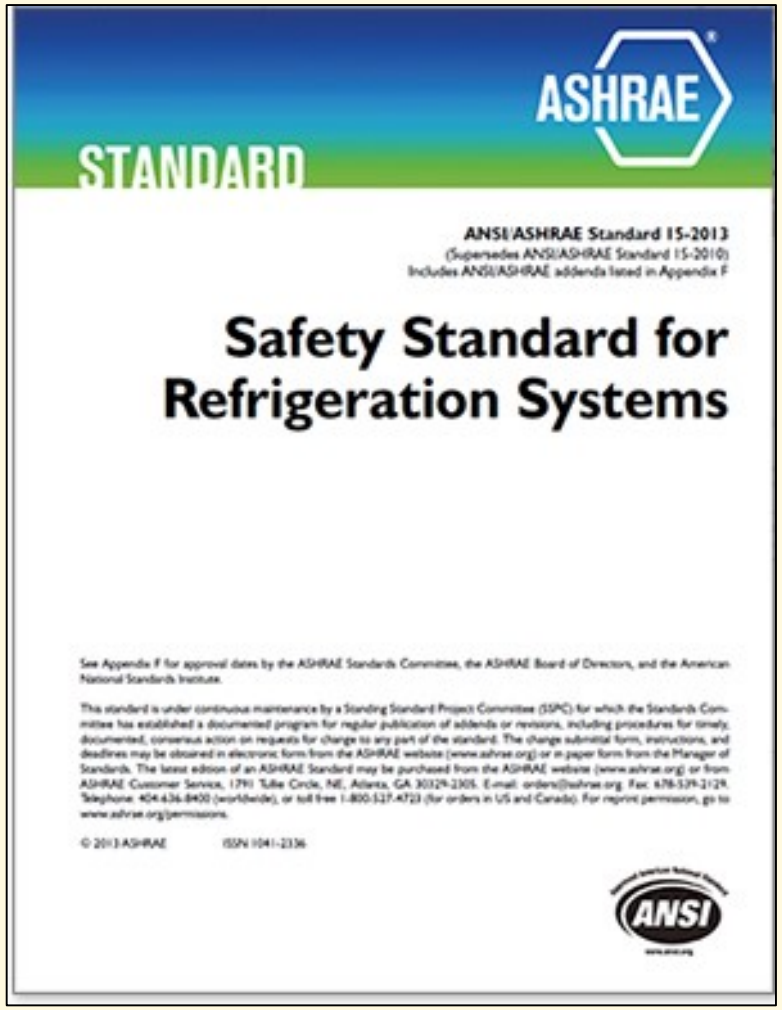


2008



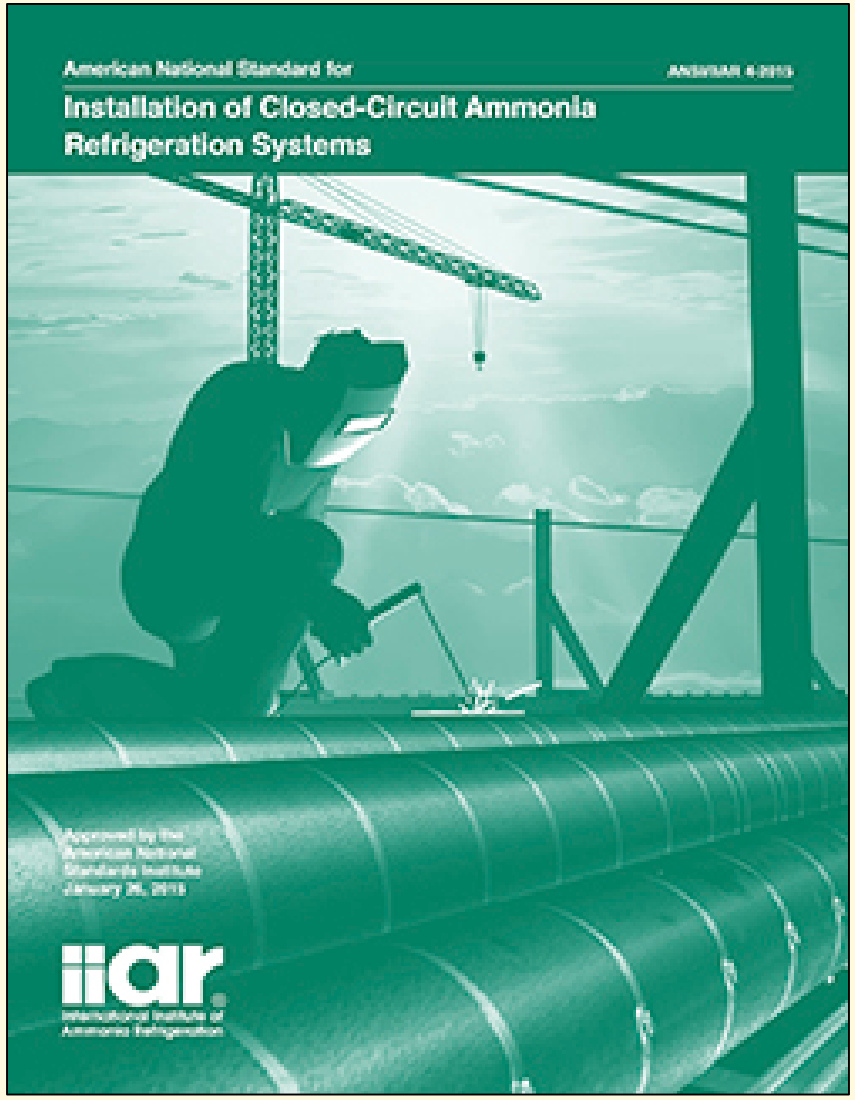
2014

IIAR 2 vs. ASHRAE 15



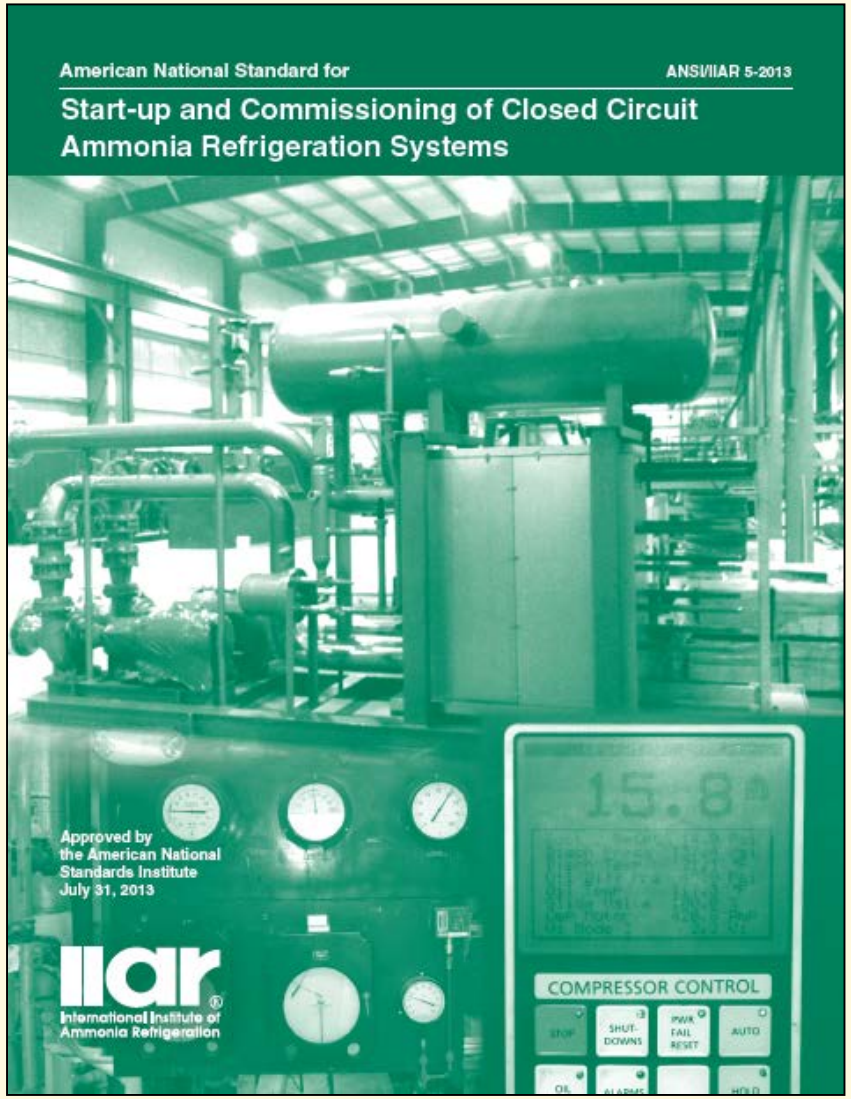
IIAR Standard 4

- ANSI/IIAR 4-2015 Installation of Closed Circuit Ammonia Refrigeration Systems



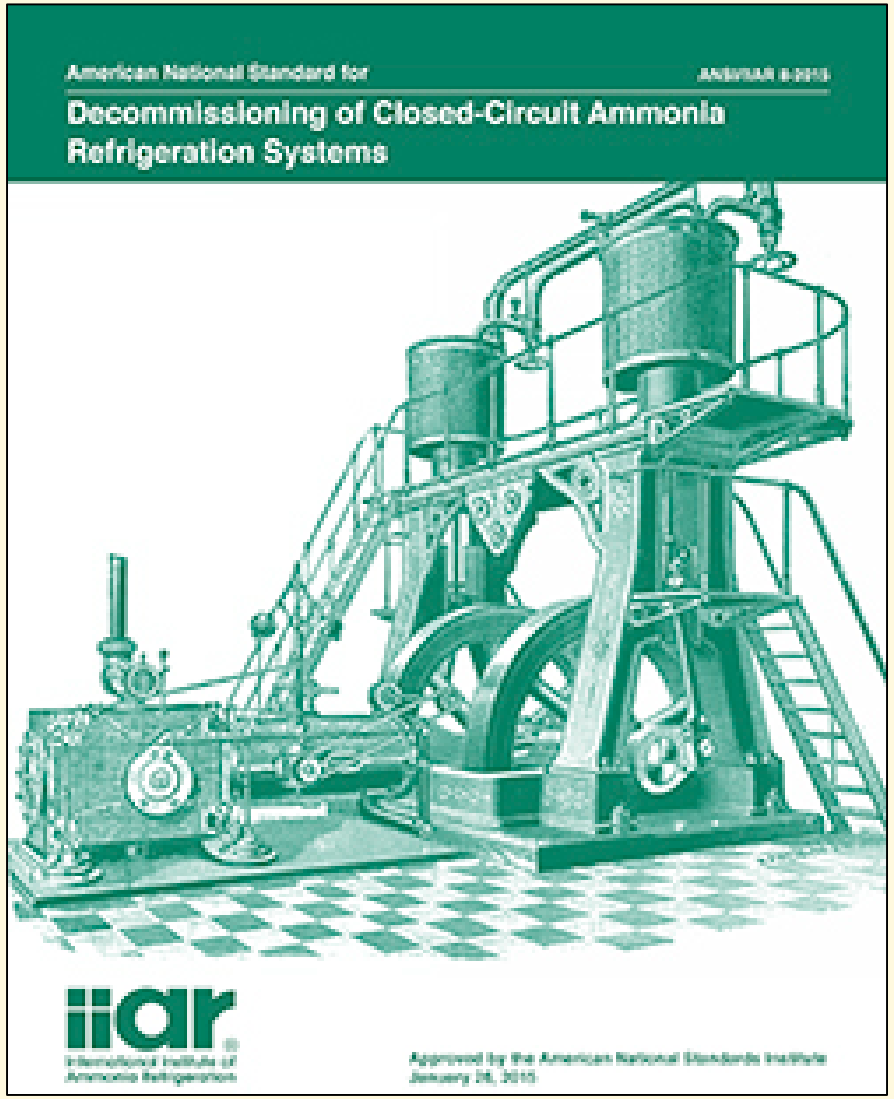
IIAR Standard 5

- ANSI/IIAR 5-2013 Start-up and Commissioning of Closed Circuit Ammonia Refrigeration Systems



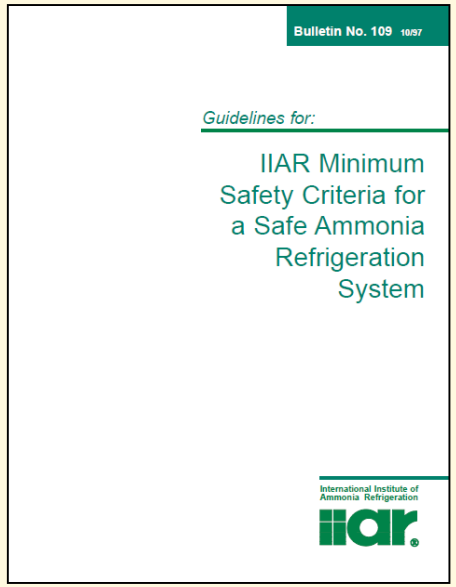
IIAR Standard 8

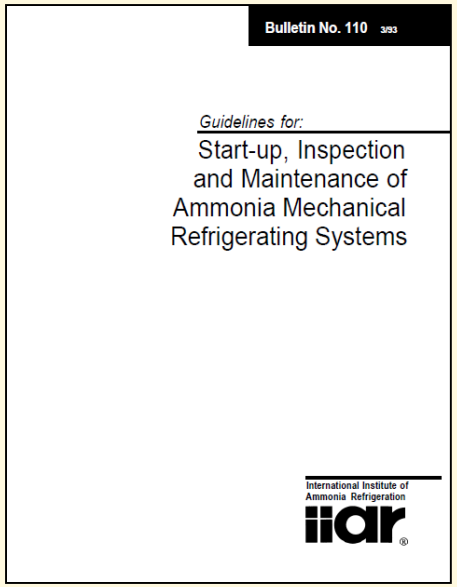
- ANSI/IIAR 8-2015 Decommissioning of Closed Circuit Ammonia Refrigeration Systems



IIAR Bulletins

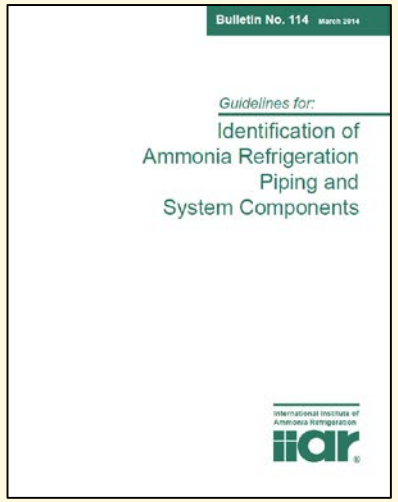
- IIAR Bulletin No. 109 *Guidelines for: IIAR Minimum Safety Criteria for a Safe Ammonia Refrigeration System*
- IIAR Bulletin No. 110 *Guidelines for: Start-up, Inspection and Maintenance of Ammonia Mechanical Refrigerating Systems*
  - Coming Soon → ANSI/IIAR 6

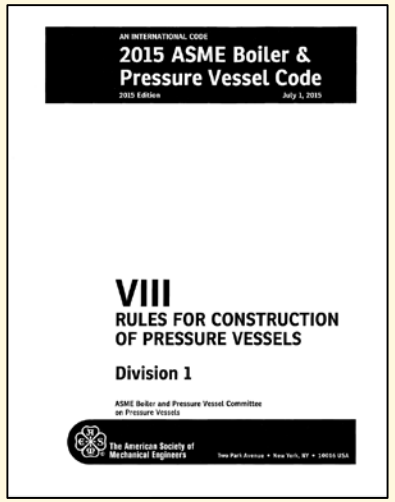


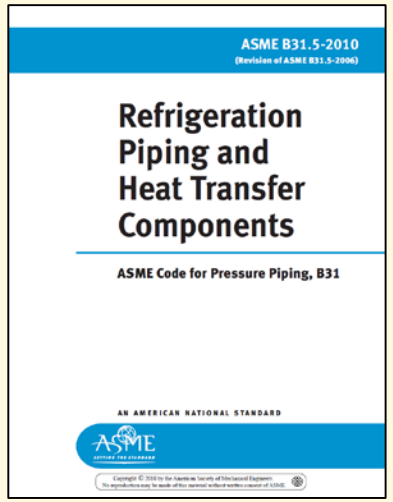


Other Important Documents

- IIAR Bulletin No. 114 *Guidelines for: Identification of Ammonia Refrigeration Piping and System Components*
- International Mechanical/Fire Code
- ASME B31.5 *Refrigeration Piping Code*
- ASME Boiler and Pressure Vessel Code Section VIII *Rules for the Construction of Pressure Vessels*
- ANSI/ISEA Z358.1-2014 *Emergency Eyewash and Shower Equipment*







Bulletins

Bulletin No. 114 March 2014

Guidelines for:

Identification of Ammonia Refrigeration Piping and System Components

International Institute of Ammonia Refrigeration

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NOTICE

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

The International Institute of Ammonia Refrigeration makes no warranty or representation, and assumes no liability or responsibility, in connection with any information contained in this document.

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

The Institute does not "approve" or "endorse" any products, services or methods. This document should not be used or referenced in any way which would imply such approval or endorsement.

Standards

This document is intended to serve as a standard for equipment, design and installation of closed-circuit ammonia refrigerating systems. Additional requirements may be necessary because of particular circumstances, project specifications or other jurisdictional considerations. Note that this standard does not constitute a comprehensive detailed technical design manual and should not be used as such.

IIAR Suite of Standards

- **ANSI/IIAR 1** Definitions and Terminology Used in IIAR Standards
- **ANSI/IIAR 2** Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems
- **ANSI/IIAR 3** Ammonia Refrigeration Valves
- **ANSI/IIAR 4** Installation of Closed-Circuit Ammonia Mechanical Refrigeration Systems
- **ANSI/IIAR 5** Start-up and Commissioning of Closed-Circuit Ammonia Refrigeration Systems
- **ANSI/IIAR 6** Maintenance and Inspection of Closed-Circuit Ammonia Mechanical Refrigeration Systems
- **ANSI/IIAR 7** Developing Operating Procedures for Closed-Circuit Ammonia Mechanical Refrigerating Systems
- **ANSI/IIAR 8** Decommissioning of Closed-Circuit Ammonia Mechanical Refrigeration Systems
- **ANSI/IIAR 9** RAGAGEP Standard

RAGAGEP Confusion

- 2013 CMC §1102.1
  - Except as modified by this code, refrigeration system shall comply with **ASHRAE 15.** In addition, ammonia refrigeration systems shall comply with **IIAR 2**.
- ANSI/IIAR 2-2014 §5.7.2.1
  - Cast iron, malleable iron, nodular iron, steel, cast steel, and alloy steel shall be permitted in accordance with **ASME B31.5** or **ASME B&PVC, Section VIII, Division 1**. Other metallic materials, including but not limited to aluminum, aluminum alloys, lead, tin, and lead-tin alloys shall be permitted in accordance with Section 5.7.1. Where tin and tin-lead alloys are used, the alloy composition shall be verified as suitable for temperature exposures, as specified in Section 5.6.

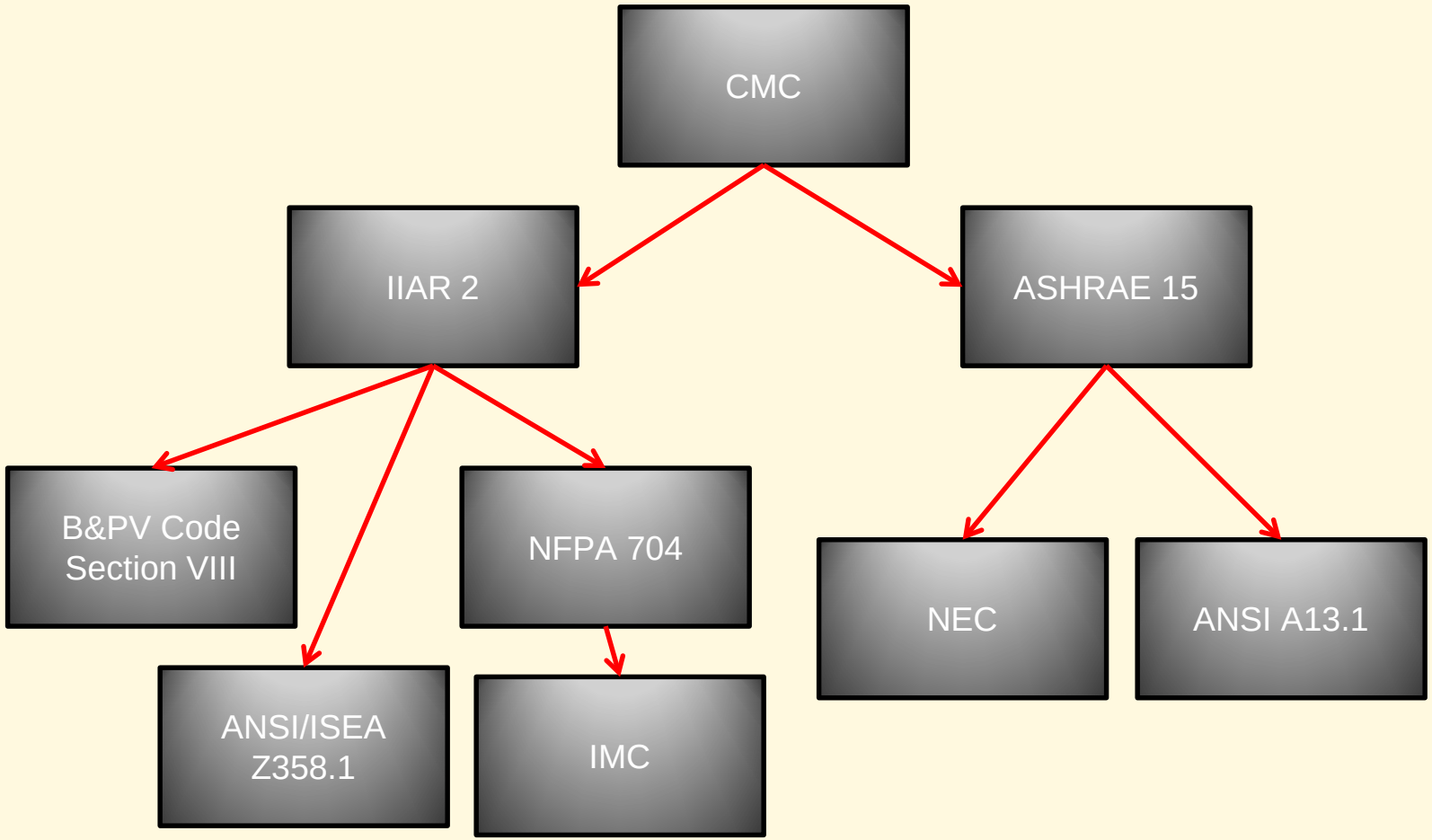
RAGAGEP Confusion

- ANSI/IIAR 2-2014 §6.7.3
  - Emergency eyewash/safety shower unit installations shall comply with **ANSI/ISEA Z358.1**.
- ANSI/IIAR 2-2014 §6.15.1
  - Buildings and facilities with refrigeration systems shall be provided with placards accordance with **NFPA 704** and the **Mechanical Code**.

RAGAGEP Confusion

- ANSI/ASHRAE 15-2013 §11.2.2
  - the kind of refrigerant or secondary coolant contained in exposed piping outside the machinery room. Valves or piping adjacent to valves shall be identified in accordance with **ANSI A13.1, Scheme for Identification of Piping Systems**.
- ANSI/ASHRAE 15-2013 §8.5
  - Electrical Safety. Electrical equipment and wiring shall be installed in accordance with the **National Electrical Code** and the requirements of the AHJ.

RAGAGEP Confusion



IIAR and Model Codes

- **2015 IFC §606.12.1.1 Ammonia refrigeration.** Refrigeration systems using ammonia refrigerant and the buildings in which such systems are installed shall comply with IIAR-2 for system design and installation and IIAR-7 for operating procedures.
- **2015 NFPA 1 §53.1.3 Reference Codes and Standards.** Refrigeration systems shall be in accordance with ASHRAE 15 and the mechanical code. Refrigeration systems using ammonia as a refrigerant shall also comply with ANSI/IIAR 2, Standard for Equipment, Design and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems.

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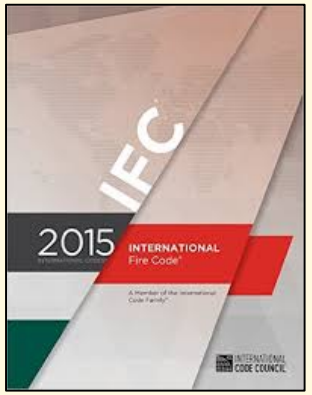

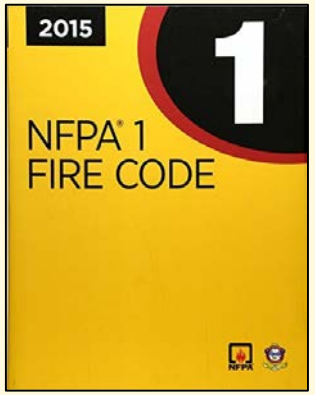

IIAR and Model Codes

- **2015 UMC §1102.1 General.** Refrigeration systems shall comply with this chapter and ASHRAE 15.
  Exception: Ammonia refrigeration systems shall comply with IIAR 2, IIAR 3, and IIAR 5.
- **2015 IMC §1101.6 General.** Refrigeration systems shall comply with the requirements of this code and, except as modified by this code, ASHRAE 15. Ammonia-refrigerating systems shall comply with this code and, except as modified by this code, ASHRAE 15 and IIAR 2.

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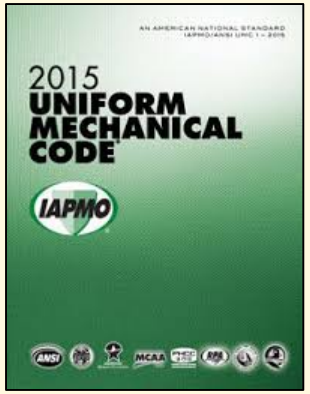

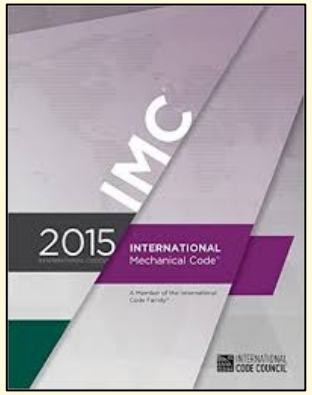

IIAR and Model Codes

- **NFPA 70-2017 §505.5** Refrigerant machinery rooms that contain ammonia refrigeration systems and are equipped with adequate mechanical ventilation that operates continuously or is initiated by a detection system at a concentration not exceeding 150 ppm shall be permitted to be classified as “unclassified” locations. Informational Note: For further information regarding classification and ventilation of areas involving closed-circuit ammonia refrigeration systems, see ANSI/ASHRAE 15-2013, Safety Standard for Refrigeration Systems , and ANSI/IIAR 2-2014, Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems.

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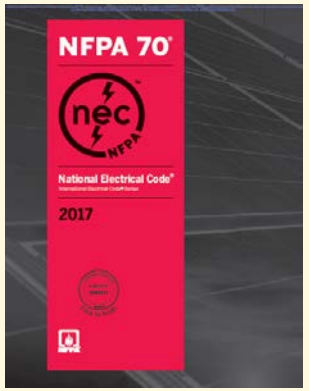
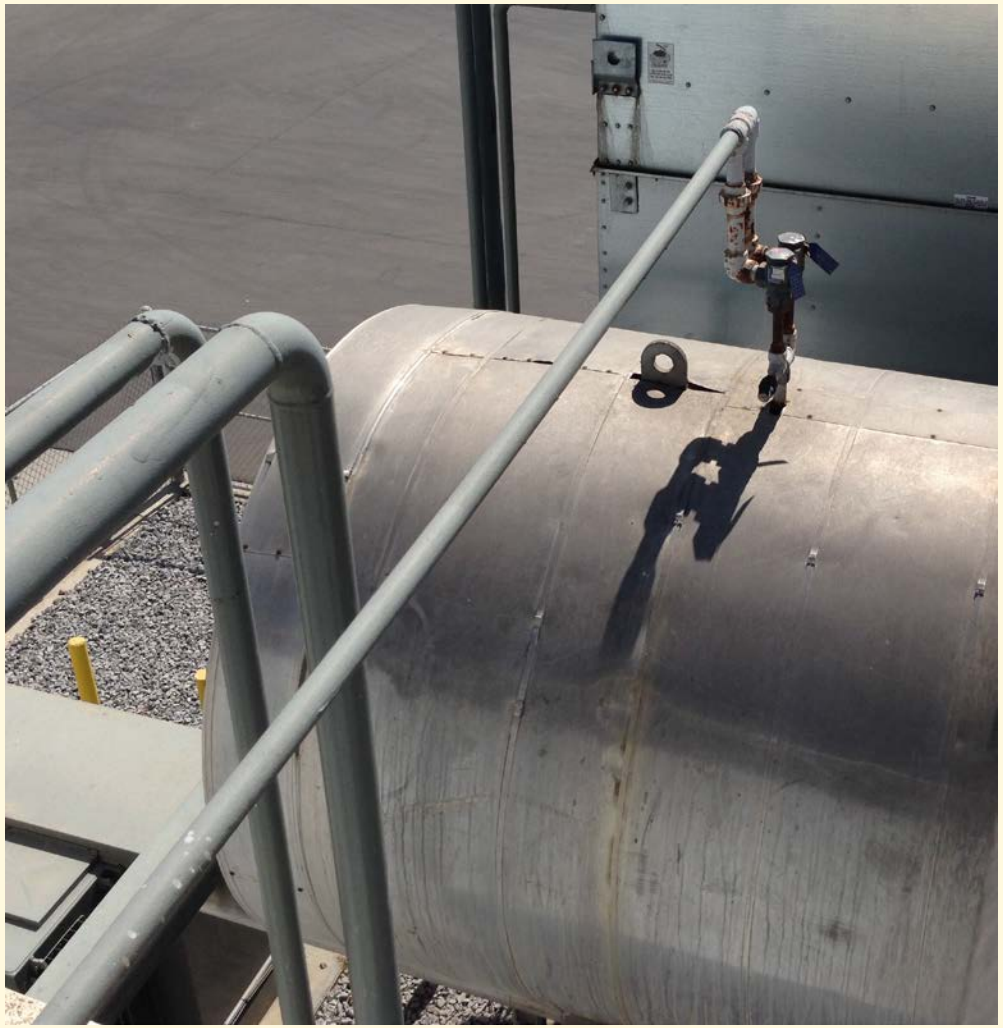


CalARP Proposed Change

(iii) "Recognized and Generally Accepted Good Engineering Practices (RAGAGEP)" means engineering, operation, or maintenance activities based on codes, standards, technical reports or recommended practices published by the American National Standards Institute (ANSI), American Petroleum Institute (API), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), American Society of Mechanical Engineers (ASME), American Society of Testing and Materials (ASTM), National Fire Protection Association (NFPA), Instrument Society of America (ISA), or other standard-setting organizations. RAGAGEP does not include standards or guidelines developed for internal use by the owner or operator.

Conflicts in RAGAGEP

- **Maximum Length of Relief Valve Discharge Piping**



Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

- 2012 Uniform Mechanical Code §1118.1
  - The maximum length of the discharge piping permitted to be installed on the outlet of a pressure-relief device shall be determined by:

$$L = \frac{9P^2d^5}{16C^2}$$

Where

C = Minimum required discharge capacity, pounds of air per minute

d = Internal diameter of pipe, inches

L = Length of discharge pipe, inches

Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

- 2012 International Mechanical Code §1105.8 *Ammonia discharge*.
  - Pressure relief valves for ammonia systems shall discharge in accordance with ASHRAE 15.

Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

- ASHRAE 15-2013 §9.7.8.5
  - The maximum length of the discharge piping installed on the outlets of pressure-relief devices and fusible plugs discharging to the atmosphere shall be determined by the method in Normative Appendix D.

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \times ln(P_0/P_2)}{6f}$$

Where

L = equivalent length of discharge piping, ft (m)

C_r = rated capacity as stamped on the relief device in lb/min

f = Moody friction factor in fully turbulent flow

d = inside diameter of pipe or tube, in. (mm)

P_2 = absolute pressure at outlet of discharge piping, psi (kPa)

P_0 = allowed back pressure (absolute) at the outlet of pressure relief device, psi (kPa)

Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

- ANSI/IIAR 2-2014 §15.5.1.1.1
  - The design backpressure in the discharge piping at the outlet of pressure relief devices and fusible plugs, discharging through a single relief device to atmosphere, shall be limited by the allowable equivalent length of piping determined by Equation 15.5.1.1.1(1) or 15.5.1.1.1(2).

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \times ln(P_0/P_2)}{6f}$$

Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

$$L = \frac{9P^2 d^5}{16C^2}$$

vs.

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \times ln(P_0/P_2)}{6f}$$

Conflicts in RAGAGEP

Relief Valve Discharge Termination

Conflicts in RAGAGEP

Relief Valve Discharge Termination

- 2012 International Mechanical Code §1105.8 *Ammonia discharge*.
  - Pressure relief valves for ammonia systems shall discharge in accordance with ASHRAE 15.

Conflicts in RAGAGEP

Relief Valve Discharge Termination

- 2012 Uniform Mechanical Code §1120.0 *Ammonia Discharge*.
  - Ammonia shall discharge into a tank of water that shall be used for no purpose except ammonia absorption. Not less than 1 gallon (4 L) of fresh water shall be provided for each pound (kg) of ammonia that will be released in 1 hour from the largest relief device connected to the discharge pipe…

Conflicts in RAGAGEP

Relief Valve Discharge Termination

- ANSI/ASHRAE 15-2013 §9.7.8.2 *Ammonia Discharge*.
  - Ammonia from pressure-relief valves shall be discharged into one or more of the following:
    a. The atmosphere, per Section 9.7.8
    b. A tank containing one gallon of water for each pound of ammonia (8.3 liters of water for each kilogram of ammonia) that will be released in one hour from the largest relief device connected to the discharge pipe. The water shall be prevented from freezing. The discharge pipe from the pressure-relief device shall distribute ammonia in the bottom of the tank but no lower than 33 ft (10m) below the maximum liquid level. The tank shall contain the volume of water and ammonia without overflowing.
    c. Other treatment systems that meet the requirements of the AHJ

RAGAGEP Conflicts – Best Practices

- **Documentation** - Clearly document the RAGAGEP(s) used in design and installation
  - Relief System Design and Design Basis
  - Ventilation System Design
  - Design Codes and Standards Employed

1. Relief System Design and Design Basis

The *Relief System Design and Design Basis* at Company XYZ was analyzed for conformance with the following industry standards:

- ANSI/IIAR 2-2014 §15 *Overpressure Protection Devices*
- ANSI/ASHRAE 15-2013 §9.3 *Refrigerant-Containing Pressure Vessels*
- ANSI/ASHRAE 15-2013 §9.4 *Pressure-Relief Protection*
- ANSI/ASHRAE 15-2013 §9.5 *Setting of Pressure-Relief Devices*
- ANSI/ASHRAE 15-2013 §9.6 *Marking of Relief Devices and Fusible Plugs*
- ANSI/ASHRAE 15-2013 §9.7 *Pressure Vessel Protection*
- ANSI/ASHRAE 15-2013 §9.8 *Positive Displacement Compressor Protection*
- 2016 CMC §1117.0 *Overpressure Protection*
- 2016 CMC §1118.0 *Discharge Piping*
- 2016 CMC §1119.0 *Special Discharge Requirements*
- 2016 CMC §1120.0 *Ammonia Discharge*
- 2016 CFC §606.12 *Termination of relief devices*
- 2015 ASME B&PV Code UG-125 – UG-140 *Overpressure Protection*
- IIAR Bulletin No. 110 §6.6.3 *Pressure Relief Devices*
- *Engineering Safety Relief Systems*, March 2006

RAGAGEP Conflicts – Best Practices

Design and Installation Codes and Standards Employed

To the best of the undersigned's knowledge, the *Ammonia Refrigeration Project* at ACME Cold Storage was designed and installed in accordance with the following codes and standards:

- 2016 International Mechanical Code Chapter 11 *Refrigeration*
- 2016 International Fire Code Section 606 *Mechanical Refrigeration*
- ANSI/IIAR 2-2014 *Standard for Safe Design of Closed Circuit Ammonia Refrigeration Systems*
- ANSI/IIAR 4-2015 *Installation of Closed-Circuit Ammonia Refrigeration Systems*
- ANSI/ASHRAE 15-2013 *Safety Standard for Refrigeration Systems*
- ASME B31.5-2016 *Refrigeration Piping and Heat Transfer Components*
- 2015 ASME Boiler & Pressure Vessel Code Section VIII *Rules for Construction of Pressure Vessels, Division 1*

Print Name _____ Signature _____ Date

RAGAGEP Conflicts – Best Practices

- **Communication**
  - Role of the AHJ
  - Role of the Design Engineer
  - Role of the Contractor
  - Role of Consultant / PHA Team

Grandfathering

Scenario:

- Cold Storage Facility was built in 1969 in accordance with the 1967 UMC.

1967 Uniform Mechanical Code

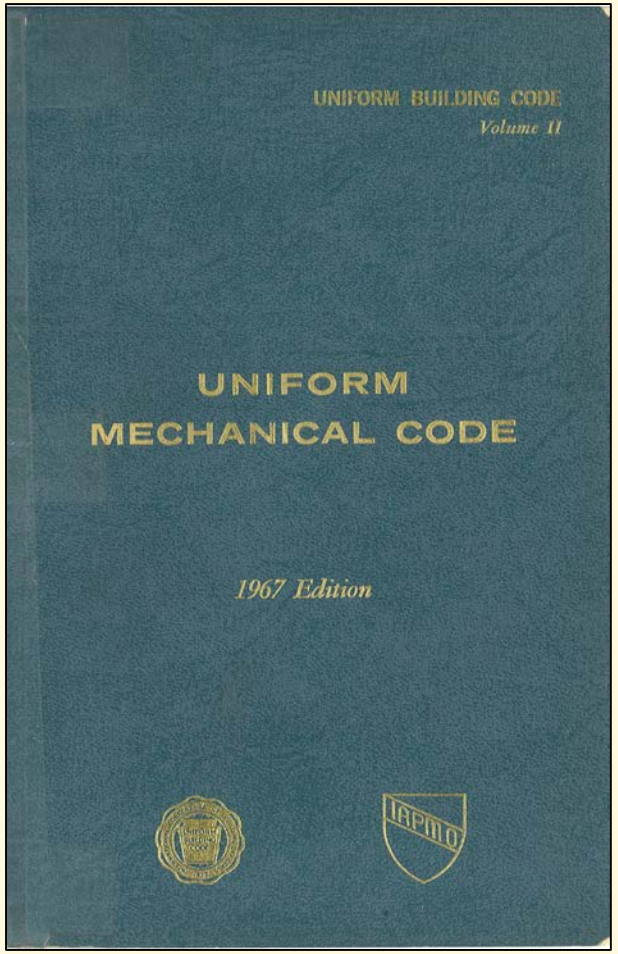
U.M.C. STANDARD 15-1-67 UNIFORM MECHANICAL CODE

UNIFORM MECHANICAL CODE STANDARD NO. 15-1-67

MECHANICAL REFRIGERATION

Based on Standard B9.1-1964 of the United States of America Standards Institute

See Section 1501, Uniform Mechanical Code

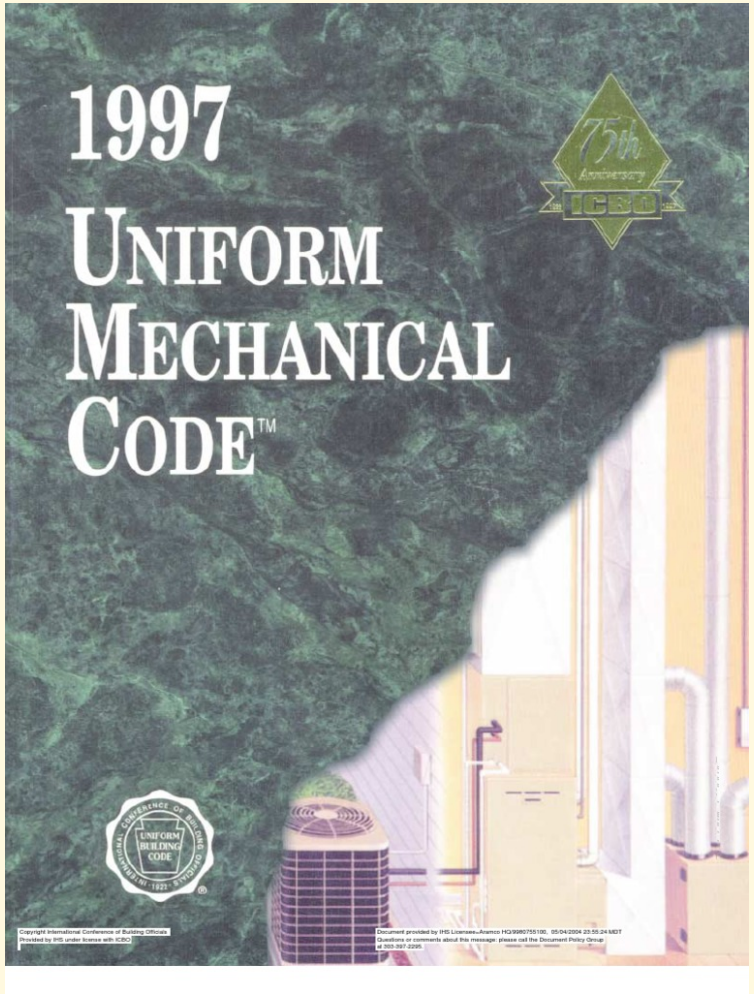


Grandfathering

Scenario:

- Cold Storage Facility was built in 1969 in accordance with the 1967 UMC.
- In 1998, modifications were made to the machinery room
  - New compressor installed
  - AHJ required ventilation and detection to be upgraded
  - All changes performed in accordance with 1997 UMC

1997 Uniform Mechanical Code



Grandfathering

Scenario:

- Cold Storage Facility was built in 1969 in accordance with the 1967 UMC.
- In 1998, modifications were made to the machinery room
  - New compressor installed
  - AHJ required ventilation and detection to be upgraded
  - All changes performed in accordance with 1997 UMC
- In 2014, facility hired a contractor to construct a new cold storage room
  - No machinery room modifications required
  - New room must comply with 2012 IMC and ANSI/IIAR 2-2008 Addendum B
  - Facility elected to upgrade detection for entire facility to comply with 2012 IMC

2012 International Mechanical Code
ANSI/IIAR 2-2008 Addendum B

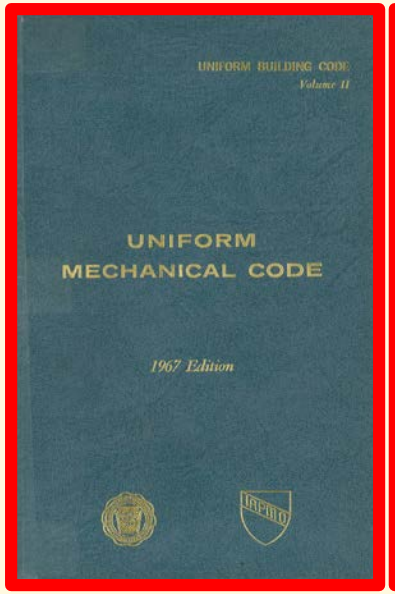
Grandfathering

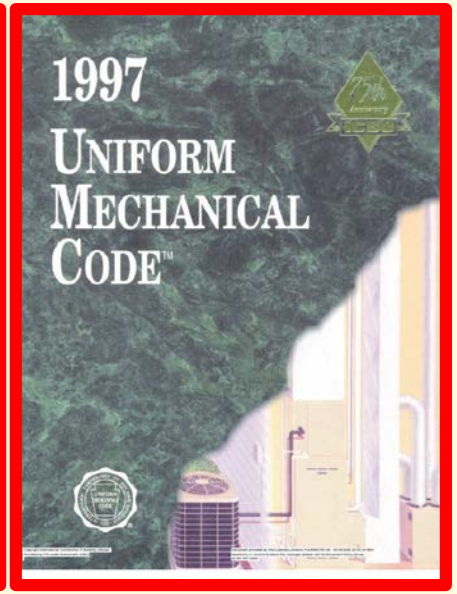
What RAGAGEP is applicable at the facility?

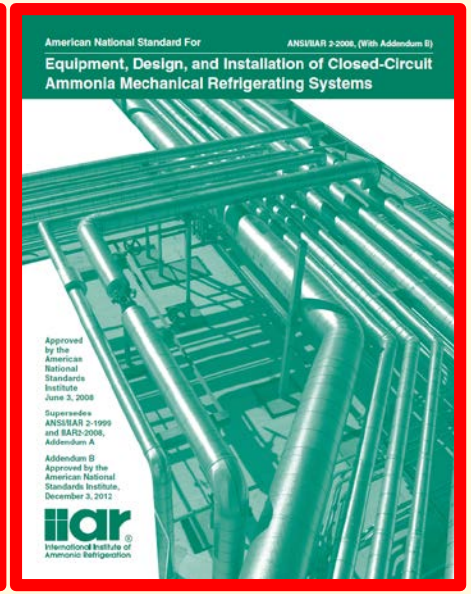
Originally Installed System

New Compressor and Ventilation System

New Room and Detection System



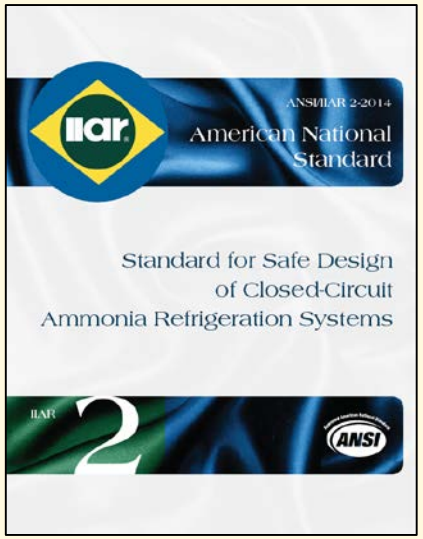


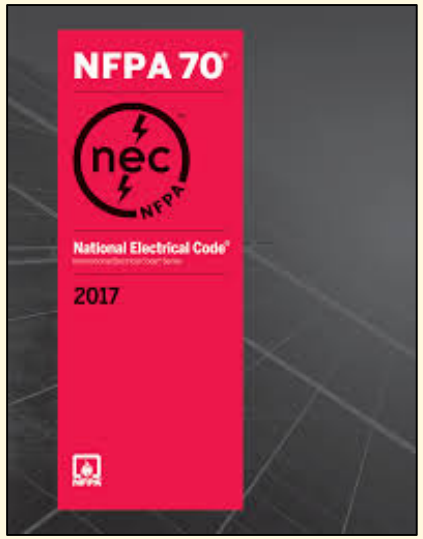


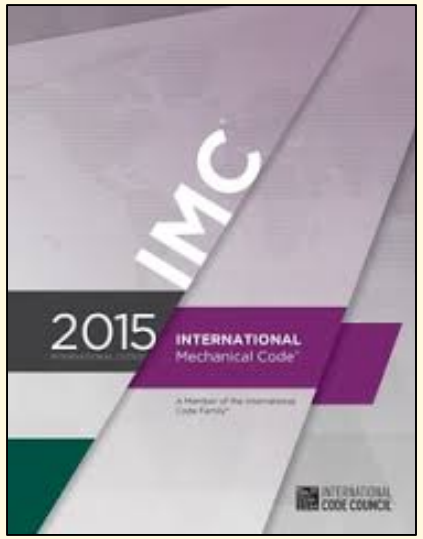
Addressing New Codes/Standards

When a new code/standard is released, what do I do?

- Role of Process Safety Information
  - §2760.1(d)(2) *The owner or operator shall document that equipment complies with recognized and generally accepted good engineering practices.*







Addressing New Codes/Standards

When a new code/standard is released, what do I do?

- Role of PHA
  - §2760.2(d) The PHA shall be performed by a team with expertise in engineering and process operations, and the team shall include at least one employee who has experience and knowledge specific to the process being evaluated. Also, one member of the team must be knowledgeable in the specific PHA methodology being used.

1: Flooded Accumulator (Surge Drum)

What If	Scenarios	Consequences	Severity	Likelihood	Risk Rankings	Safeguards
1: What if the equipment or associated components is damaged by nearby activity?	A forklift driver accidentally hits this piece of equipment.	1. Death 2. Injury 3. Low pressure liquid ammonia release 4. Reactive maintenance	4	1	C	1. The flooded accumulators are located behind bunker walls which provide some protection from forklift impact. 2. Facility forklift drivers have been trained to take extra care when driving around the refrigeration equipment. 3. The flooded accumulators are located on the roof which is inaccessible to vehicle traffic.
2: What if the back pressure	Actuator sticks in the	1. Product damage	2	3	C	1. Each room/zone is

Addressing New Codes/Standards

When a new RAGAGEP is released, what do I do?

- Role of Mechanical Integrity
  - §2760.5(d)(2) Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

Addressing New Codes/Standards

When a new technical document is released, what do I do?

- Role of Previous Incidents

Addressing New Codes/Standards