RESOURCE COMPLIANCE

Ammonia Refrigeration RAGAGEP

Peter Thomas, P.E., CSP – Resource Compliance, Inc.

RESOURCE COMPLIANCE

Providing Solutions. Simplifying Regulation.

Introduction

PSM RAGAGEP References

Title 29 §1910.119(d)(3)(ii) Process Safety Information

- The employer shall document that equipment complies with **recognized and generally accepted good engineering practices**.

Title 29 §1910.119(j)(4)(ii) Mechanical Integrity

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

Title 29 §1910.119(j)(4)(iii) 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.

RAGAGEP Citations

ABATEMENT DOCUMENTATION REQUIRED FOR THIS ITEM

Date By Which Violation Must be Abated:	07/29/2016
Proposed Penalty:	$7000.00

Citation 1 Item 2 Type of Violation: **Serious**

29 CFR 1910.119(d)(3)(ii): The employer did not document that equipment complies with recognized and generally accepted good engineering practices (RAGAGEP's).

On or about i, the employer did not document that is complied with recognized and generally accepted good engineering practices (RAGAGEP) exposing employees to the hazards of inhalation of toxic ammonia and/or fire/explosion in the following instances, see A through E:

A. The employer failed to document compliance with RAGAGEP, such as IIAR Bulletin 114 "Identification of Ammonia Refrigeration Piping and System Components" Section 4.1 "Piping Markers" and Section 5.0 (a-d) "Marker Location", March 2014, as the employer failed to mark and/or label ammonia refrigeration equipment, including:

1. Engine Room 5, Evaporating Condenser, tower EC-1
2. Engine Room 6, Evaporating Condenser, tower EC-2
3. Engine Room 7, Evaporating Condenser, towers EC-1 and EC-2
4. Engine Room 8, Evaporating Condenser, towers EC-1, EC-2 and EC-3
5. Engine Room 11, Evaporating Condenser, tower EC-1, EC-2 and EC-3

B. Failure to document compliance with RAGAGEP, such as IIAR Bulletin 110 "Guidelines for: Start-up, Inspection and Maintenance of Ammonia Mechanical Refrigerating Systems" Section 6.6 Valves and Sensing Devices Subsection 6.6.1 Shut-off Valves, as the employer failed to change out ammonia refrigeration system safety relief valves prior to their 5 year due dates from the date of installation, including:

1. Engine Room 6, Heat Exchangers 1, 2 and 3. These are dual relief systems using Hansen Valves.

Ammonia Refrigeration Code Organizations

iiar International Institute of Ammonia Refrigeration

ANSI

ICC INTERNATIONAL CODE COUNCIL®

IAPMO

ASME SETTING THE STANDARD

ASHRAE

IIAR Literature

- IIAR Bul ting Procedures When Making Ammonia Refrigera
- IIAR Bul onia Refrigeration Systems
- IIAR Bul for a Safe Am m
- IIAR Bulletin No. 110 *Guidelines for: Start-up, Inspection and Maintenance of Am Refrigerating Systems*
- IIAR Bulletin No. 111 *Guidelines for: Ammonia Machinery Room Ventilation*
- IIAR Bulletin No. 112 *Guidelines for: Ammonia Machinery Room Design*
- IIAR Bulletin No. 114 *Guidelines for: Identification of Ammonia Refrigeration Pipi ts*
- IIAR Bulletin No. 116 *Guidelines for: Avoiding Component Failure in Industrial Re by Abnormal Pressure or Shock*
- IIAR Bulletin No. R1 *A Guide to: Good Practices for the Operation of an Ammoni*

IIAR Literature - Bulletins

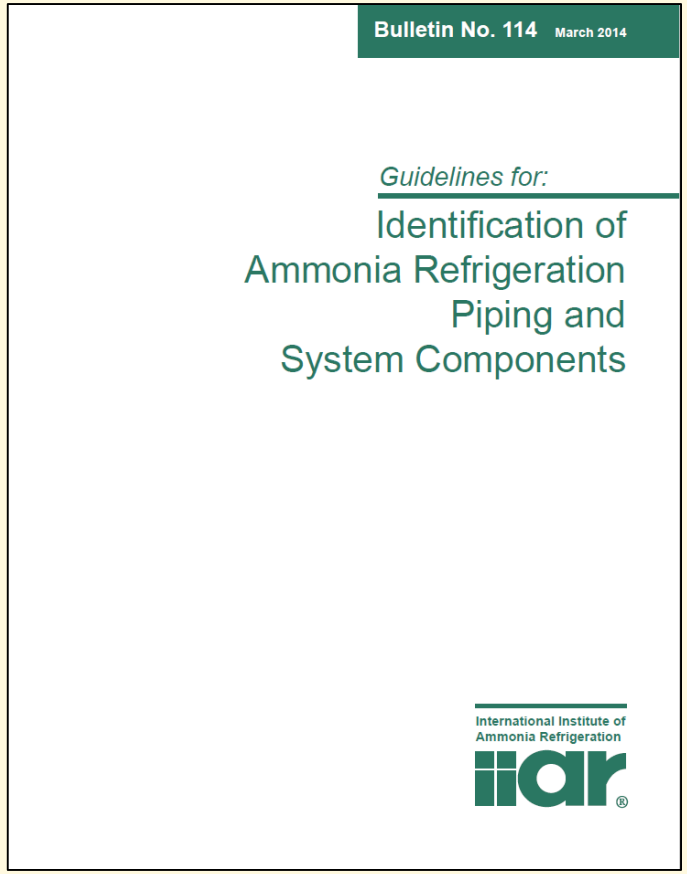
IIAR Bulletin No. 110 §6.4.2 [emphasis mine]:

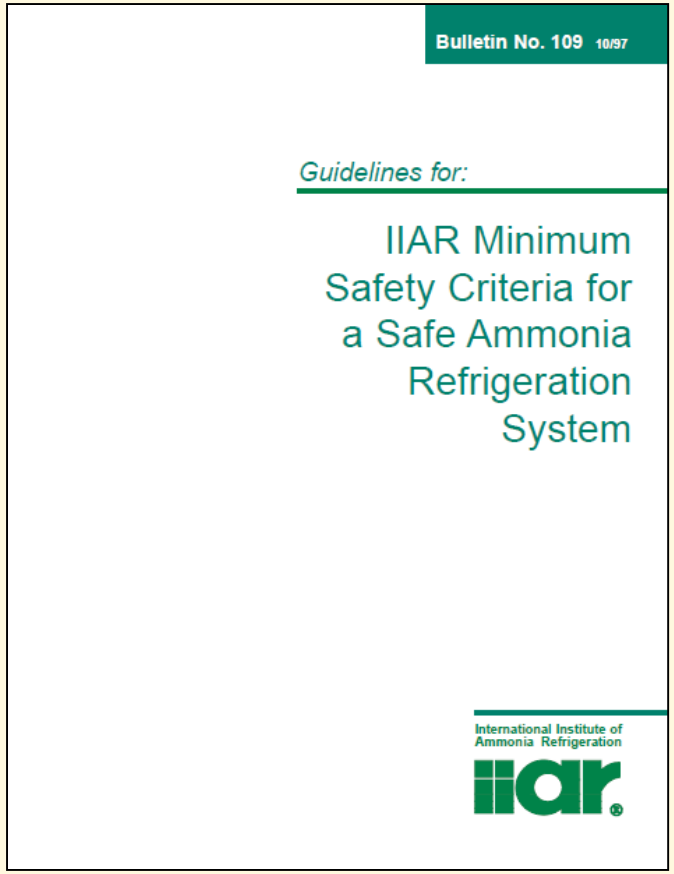
The system should be checked regularly for the presence of non-condensable gases which should be purged as necessary from the receiver(s) and/or condenser(s), preferably into a noncondensable gas remover or purger but alternatively into water. Where an automatic purger is fitted, its correct operation should be monitored. If there is a large accumulation of noncondensable gases the reason should be investigated and the cause should be corrected.

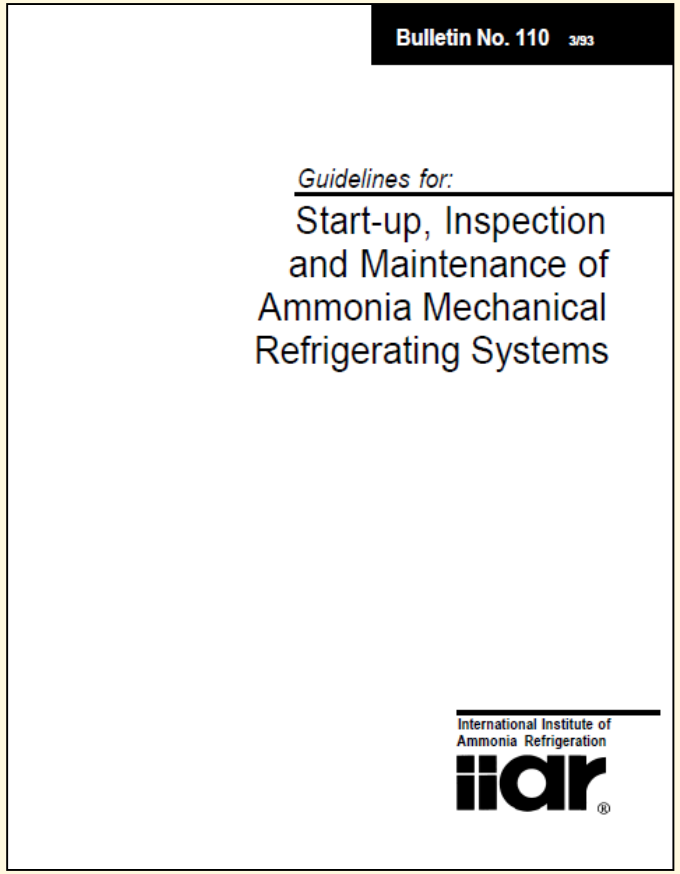
IIAR Suite of Standards

- **ANSI/IIAR 1** Definitions and Terminology Used in IIAR Standards
- **ANSI/IIAR 2** Standard for Safe Design of Closed-Circuit Ammonia Refrigeration 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
- **IIAR 6** Standard for Inspection, Testing, and Maintenance of Safe Closed-Circuit Ammonia 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
- **IIAR 9** RAGAGEP Standard

IIAR Bulletins Currently in Publication



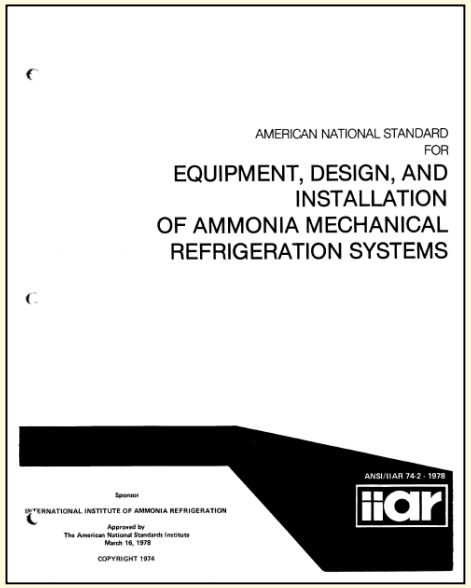




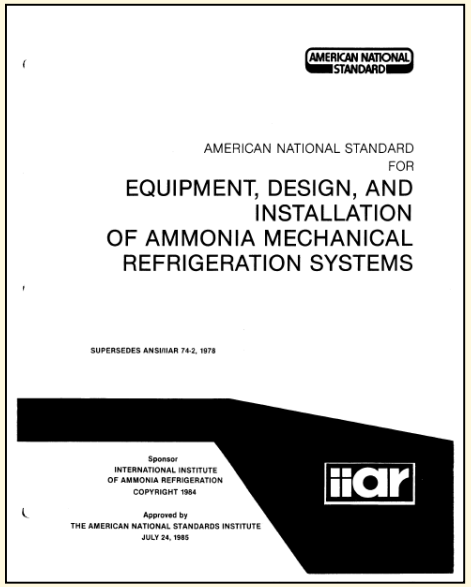
IIAR Standard 2

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

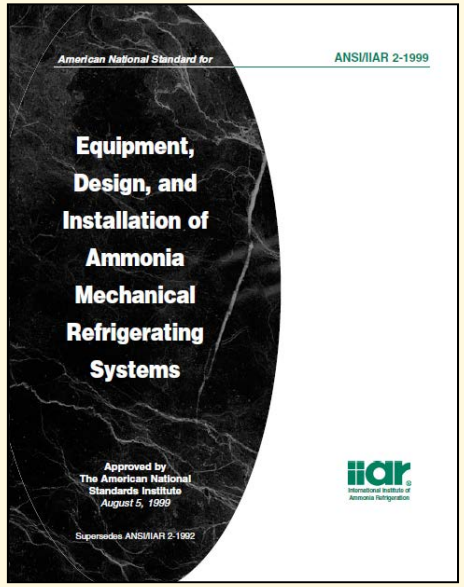
1974-78



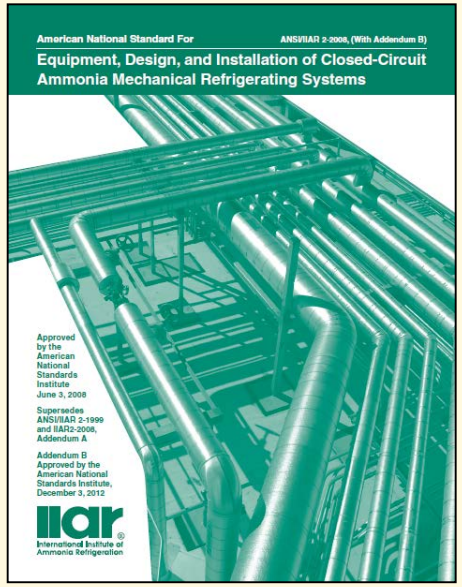
1984



1999

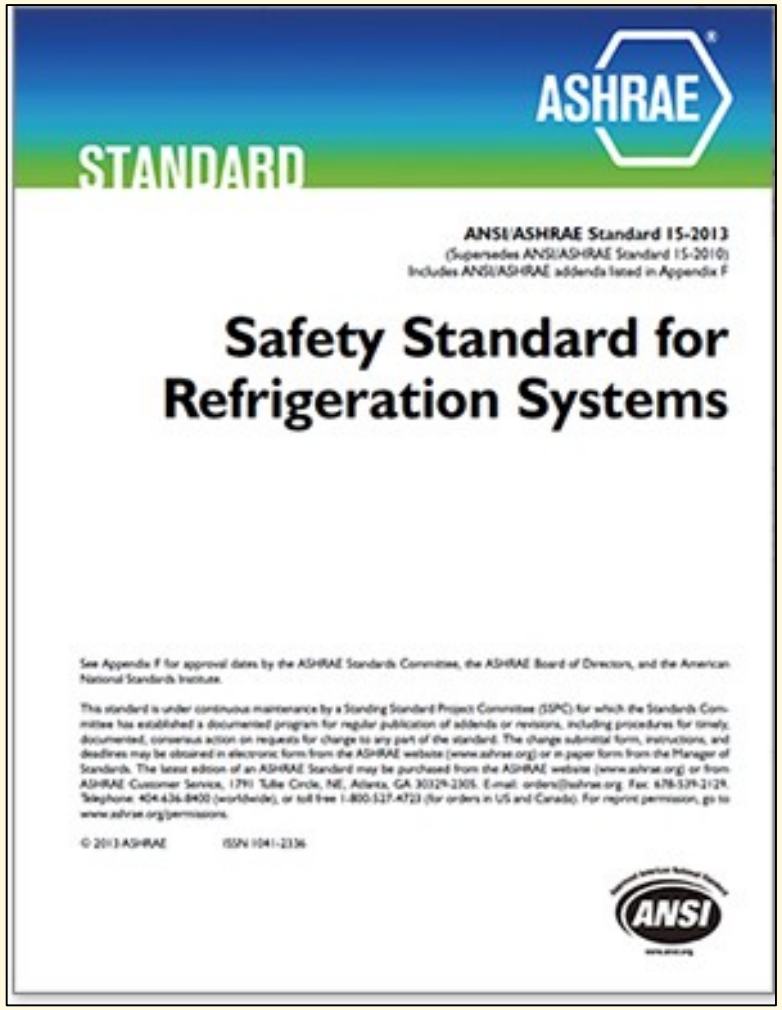


2008



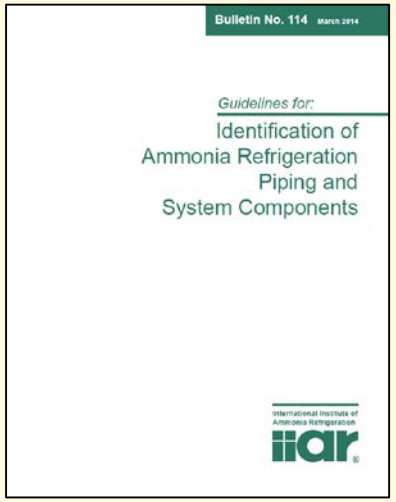
2014

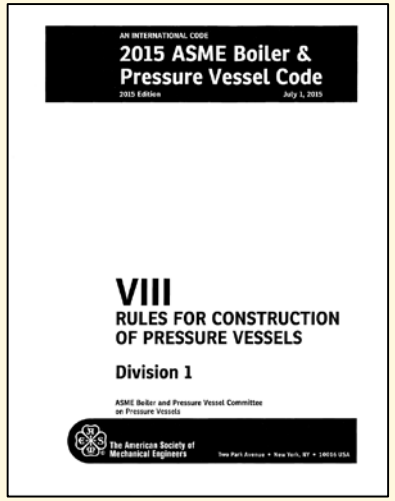
IIAR 2 vs. ASHRAE 15

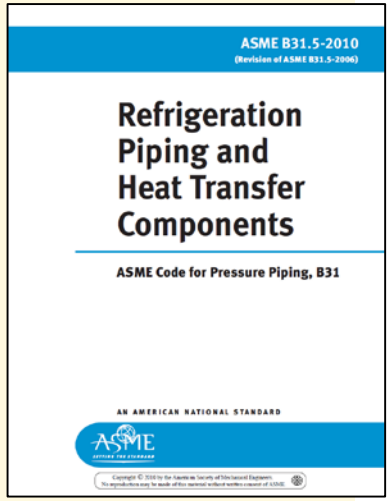


Other RAGAGEP Documents

- IIAR Bulletin No. 114 *Guidelines for: Identification of Ammonia Refrigeration Piping and System Components*
- International Mechanical/Fire Code
- ASME B31.5 *Refrigeration Piping and Heat Transfer Components*
- 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*







IIAR and Model Codes

- **2018 IFC §605.1.2 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. Decommissioning of ammonia refrigeration systems shall comply with **IIAR-8**.
- **2018 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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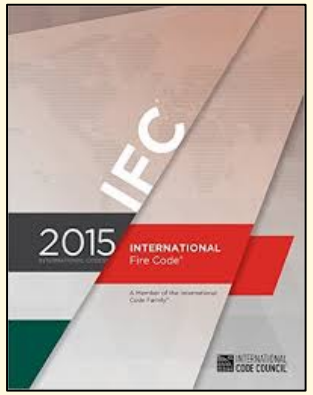

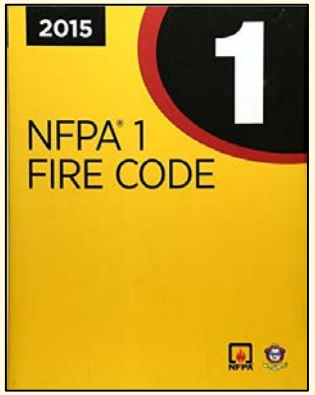

IIAR and Model Codes

- **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**.
- **2018 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, **IIAR 2**, **IIAR 3**, **IIAR 4** and **IIAR 5**.

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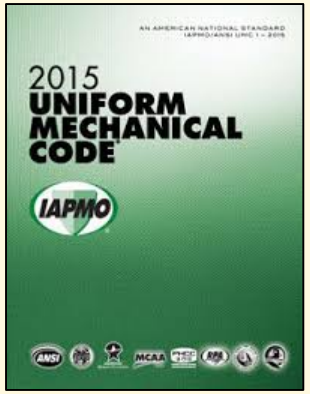

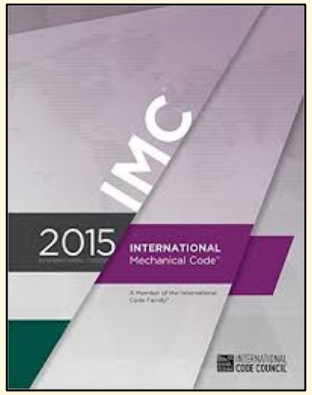

IIAR and Model Codes

- **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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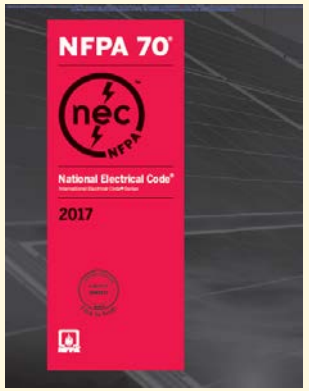
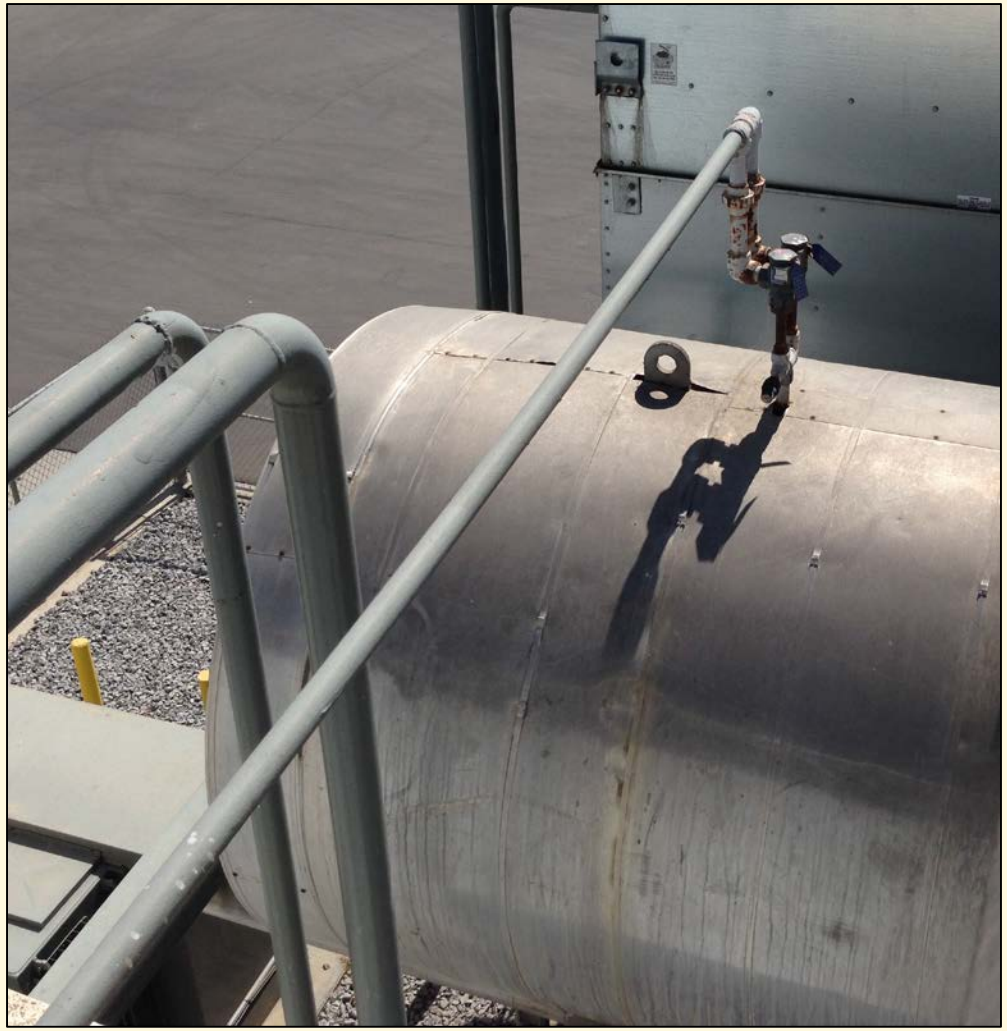


Conflicts in RAGAGEP

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



Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

2012 UMC: $L = \frac{9P^2d^5}{16C^2}$

vs.

2012 IMC: $L = \frac{0.2146d^5\left(P_0^2 - P_2^2\right)}{fC_r^2} - \frac{d \times ln(P_0/P_2)}{6f}$

Conflicts in RAGAGEP

Relief Valve Discharge Termination

Question

- When a code or standard is updated, it is the responsibility of a business to update their facility accordingly.

a) True

b) False

Grandfathering

Scenario:

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

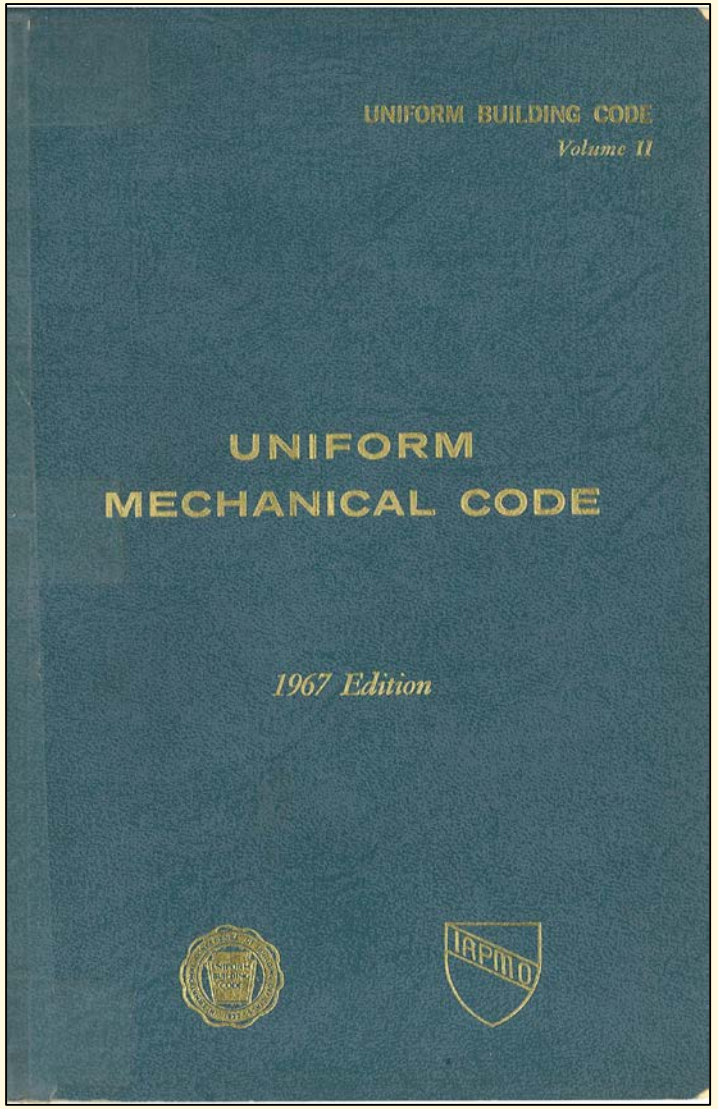
U.M.C. STANDARD 15-1-67 UNIFORM MECHANICAL CODE

UNIFORM MECHANICAL CODE STANDARD NO. 15-1-67

MECHANICAL REFRIGERATION

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

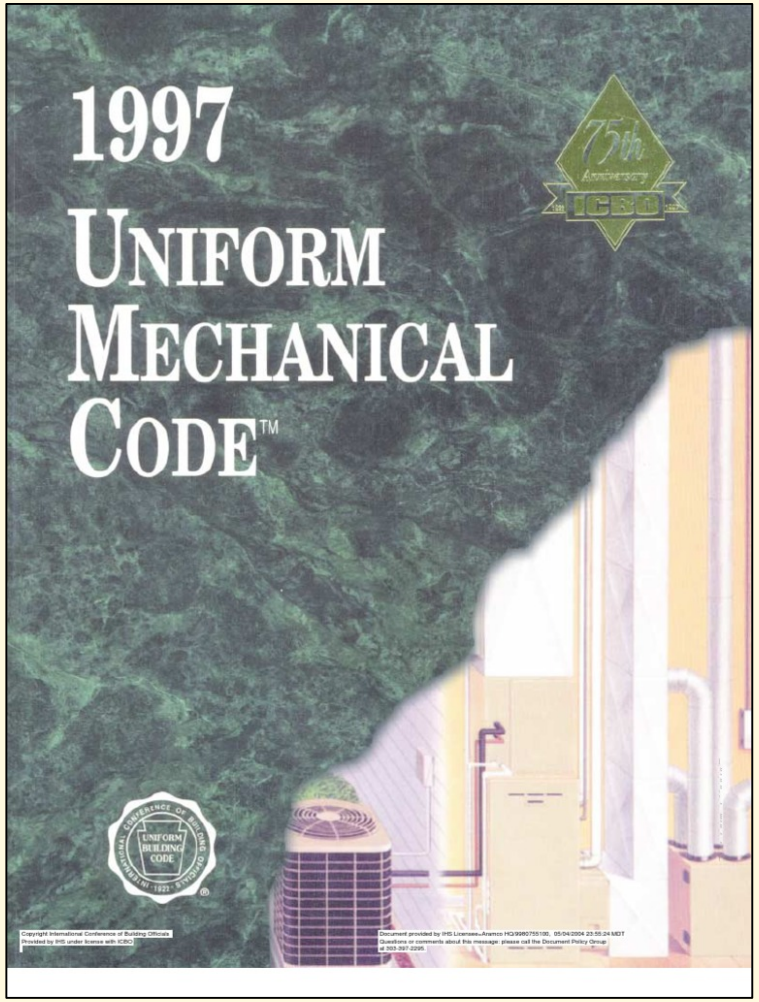
See Section 1501, Uniform Mechanical Code



Grandfathering

Scenario:

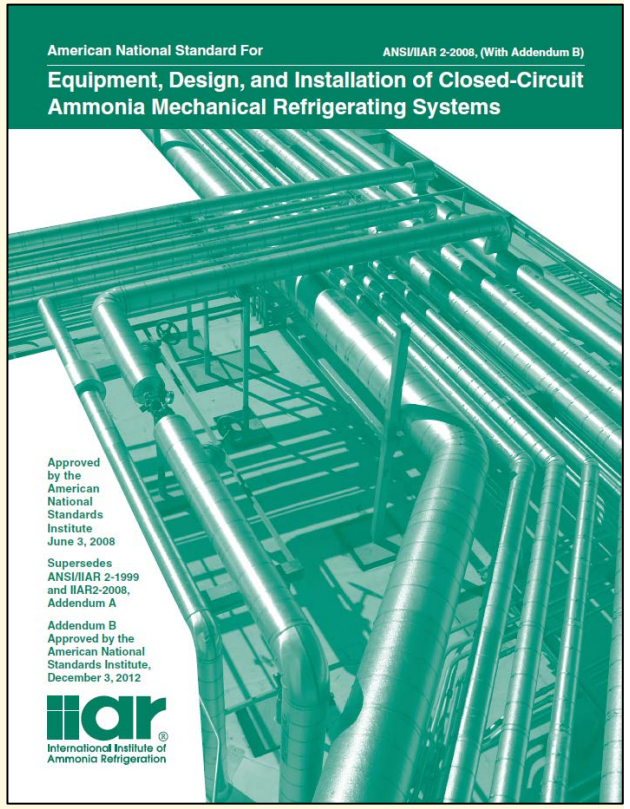
- In 1998, modifications were made to the machinery room
  - New compressor installed
  - AHJ required ventilation and detection to be upgraded
  - All changes performed in accordance with 1997 UMC



Grandfathering

Scenario:

- 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



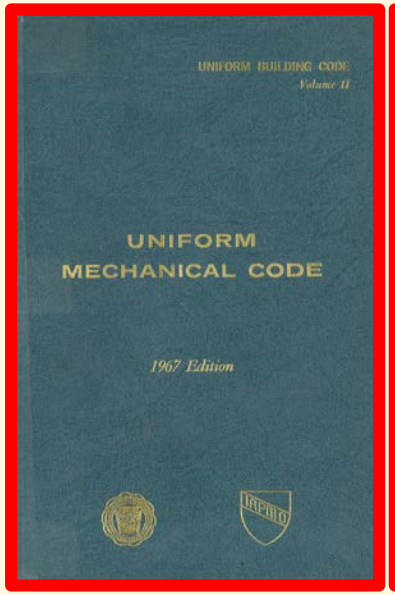
Grandfathering

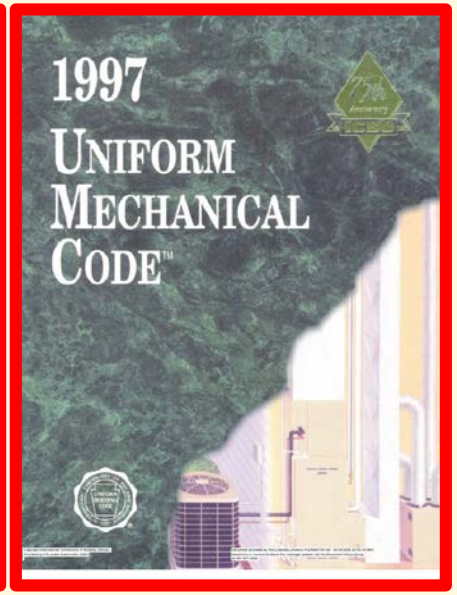
What RAGAGEP is applicable at the facility?

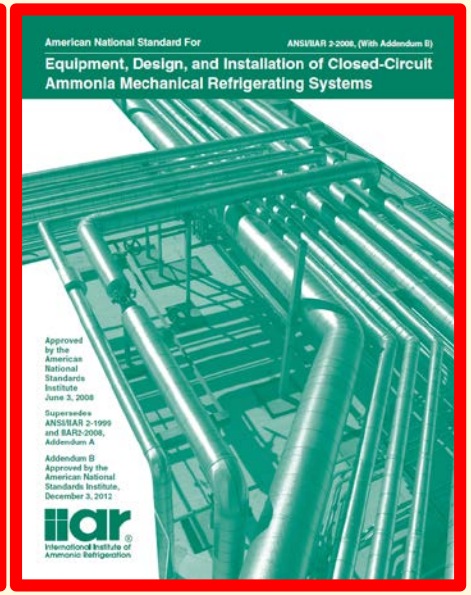
Originally Installed System

New Compressor and Ventilation System

New Room and Detection System



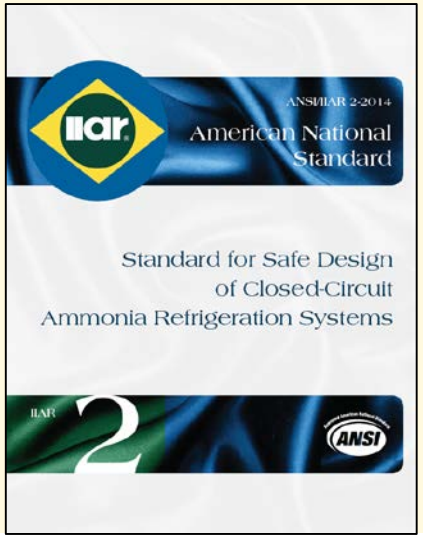


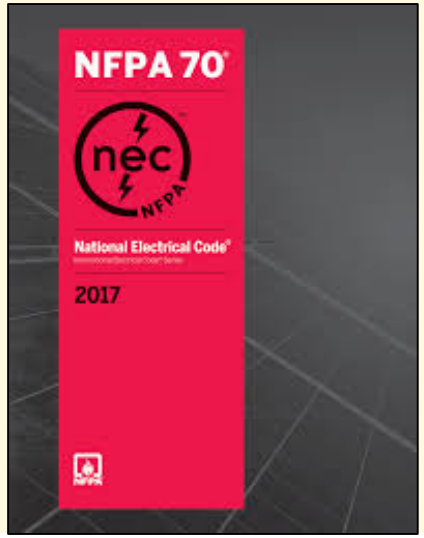


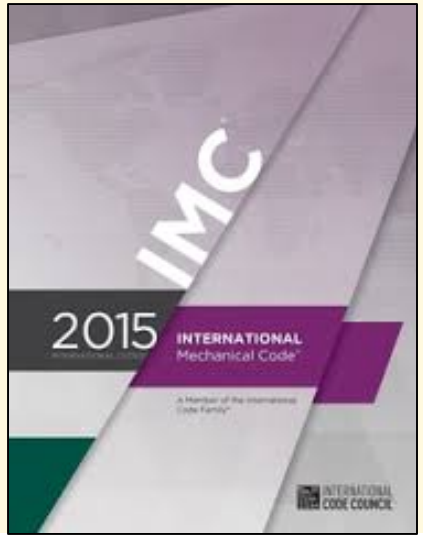
Consideration of New RAGAGEPs

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

- Role of Process Safety Information
  - Title 29 CFR §1910.119(d)(3)(ii) *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

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?

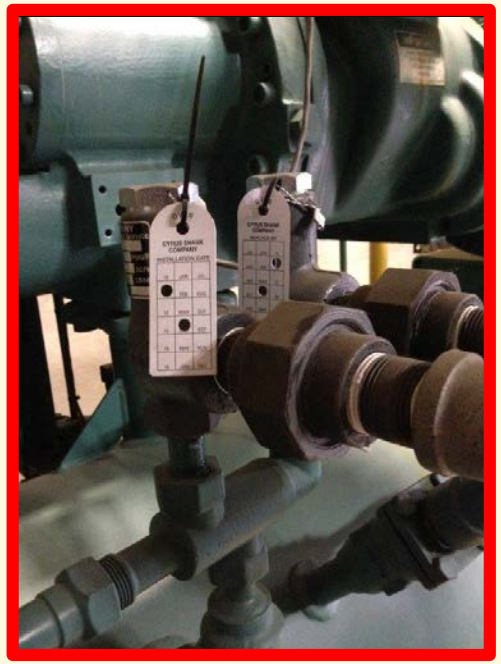
- Role of Mechanical Integrity
  - Title 29 CFR §1910.119(j)(4)(ii) Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

RESOURCE COMPLIANCE

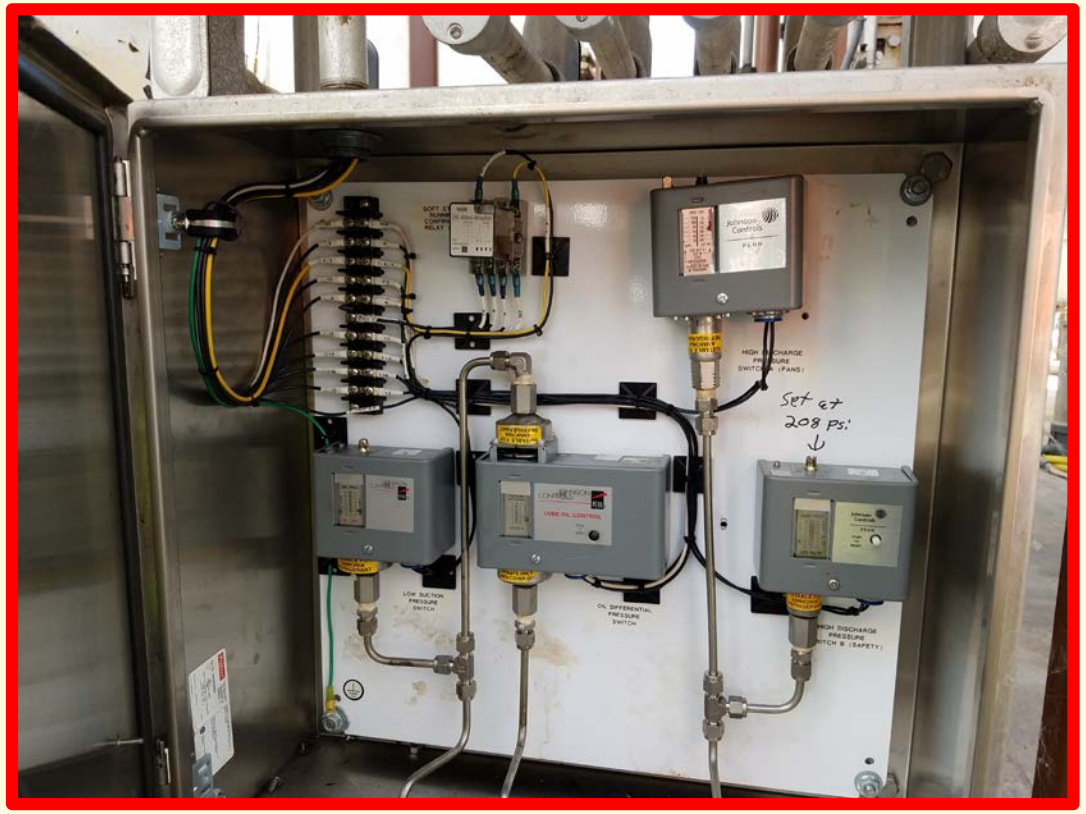
Safety Systems: Overpressure Protection

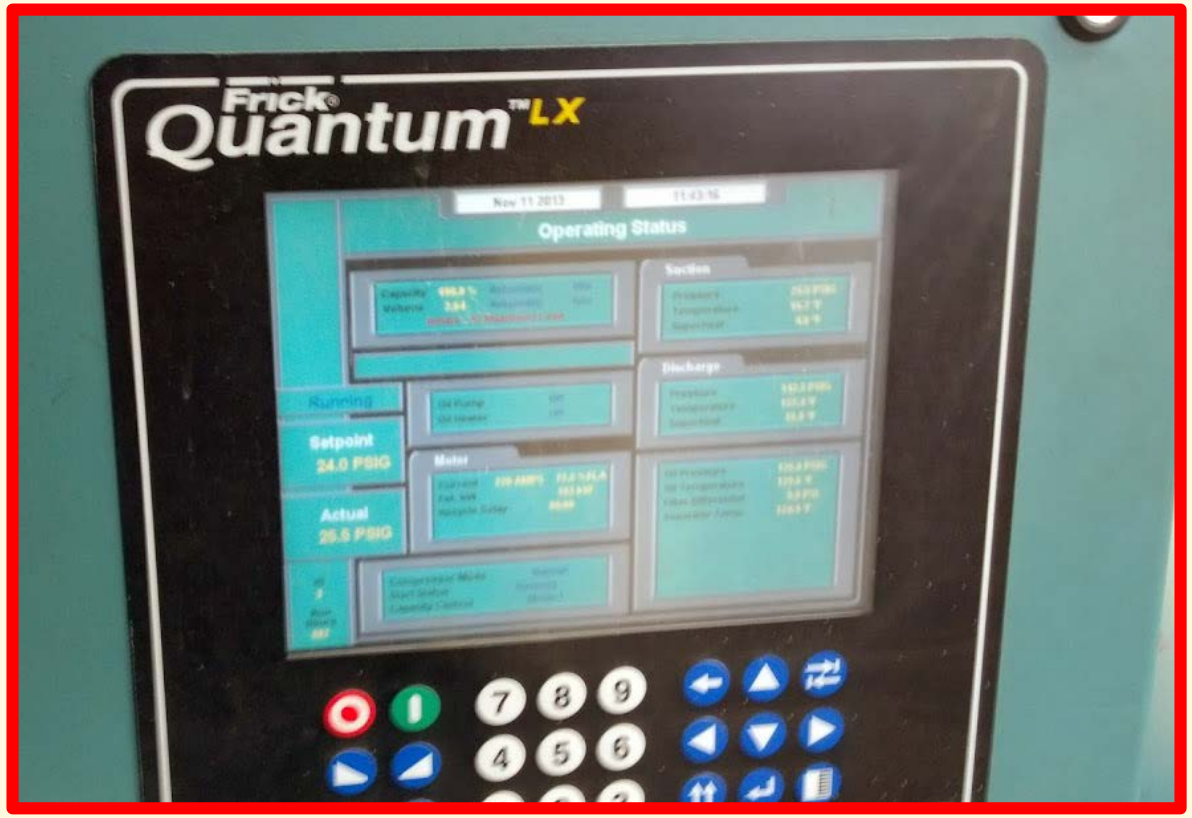
Peter Thomas, P.E., CSP – Resource Compliance, Inc.

Introduction

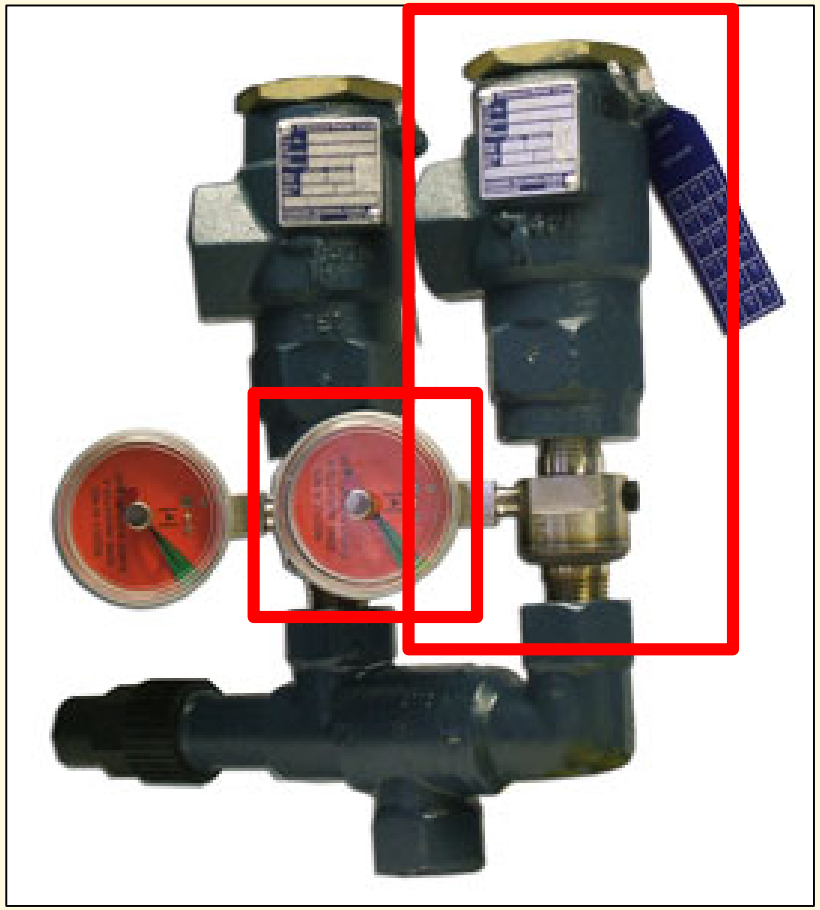


Pressure Limiting Devices





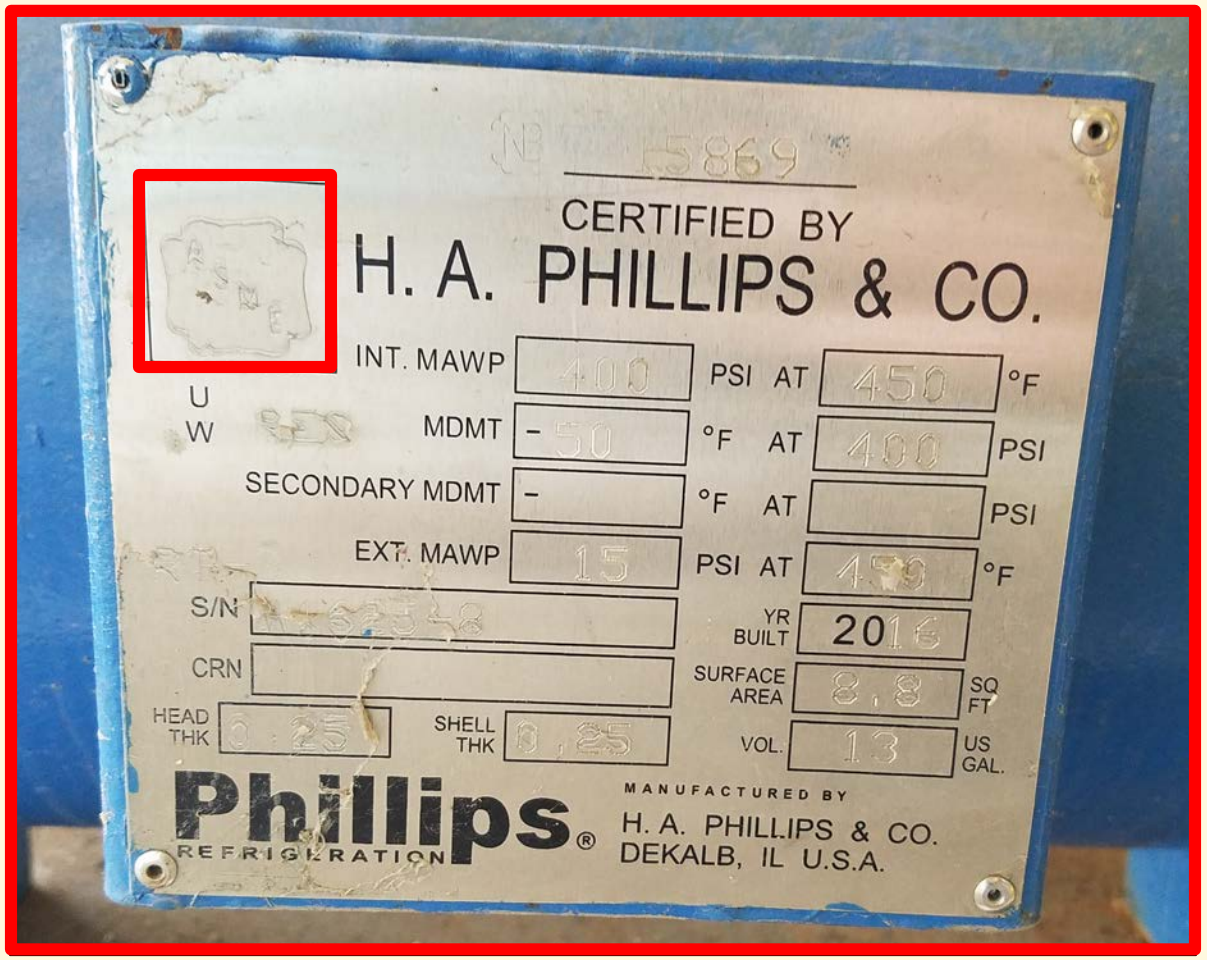
Rupture Discs



Relief Valves

Relief Valve Installation

Relief Valve Installation

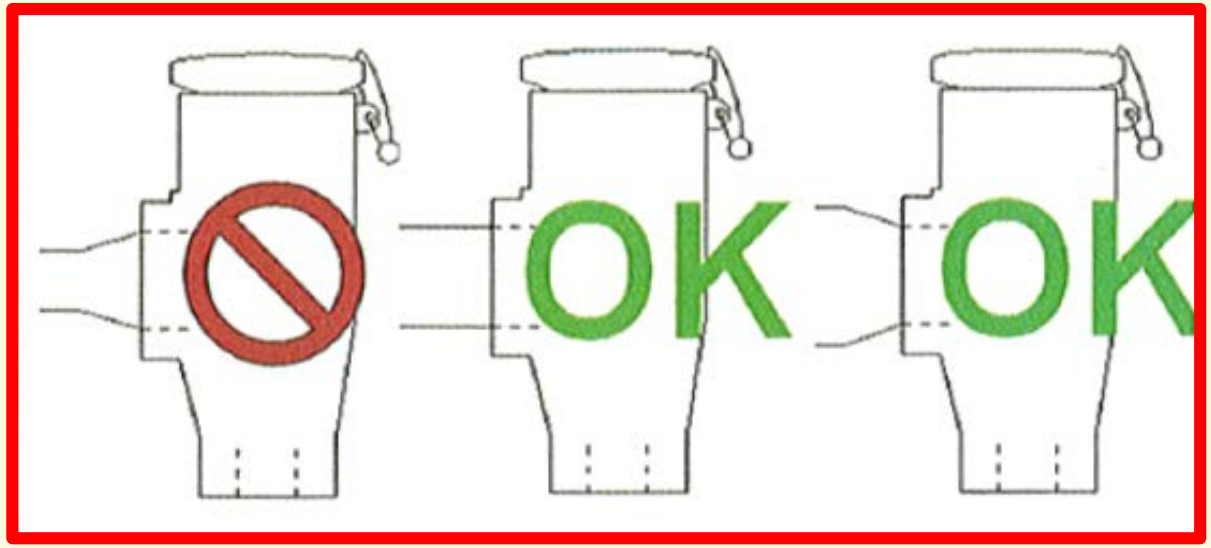


Relief Valve Installation

- **Single vs. Dual [2016 CMC §1113.6, ANSI/IIAR 2-2014 §15.3.4-§15.3.5]**
  - Pressure vessels between 3ft^3 and 10ft^3 are permitted to use a single relief valve
  - Pressure vessels greater than 10ft^3 must use a dual relief assembly

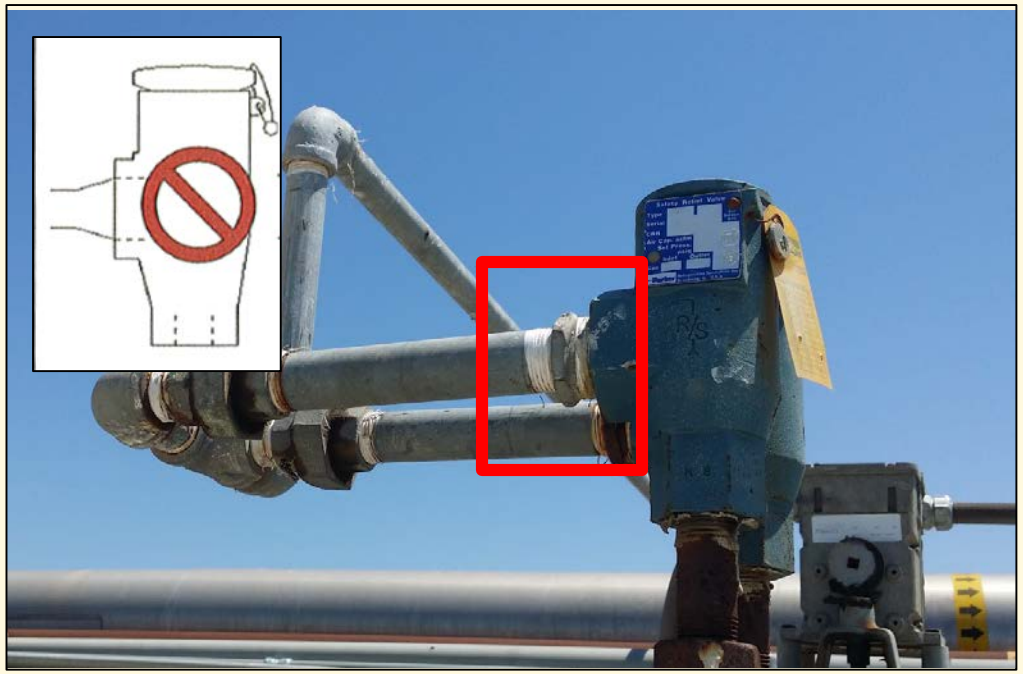
Relief Valve Installation

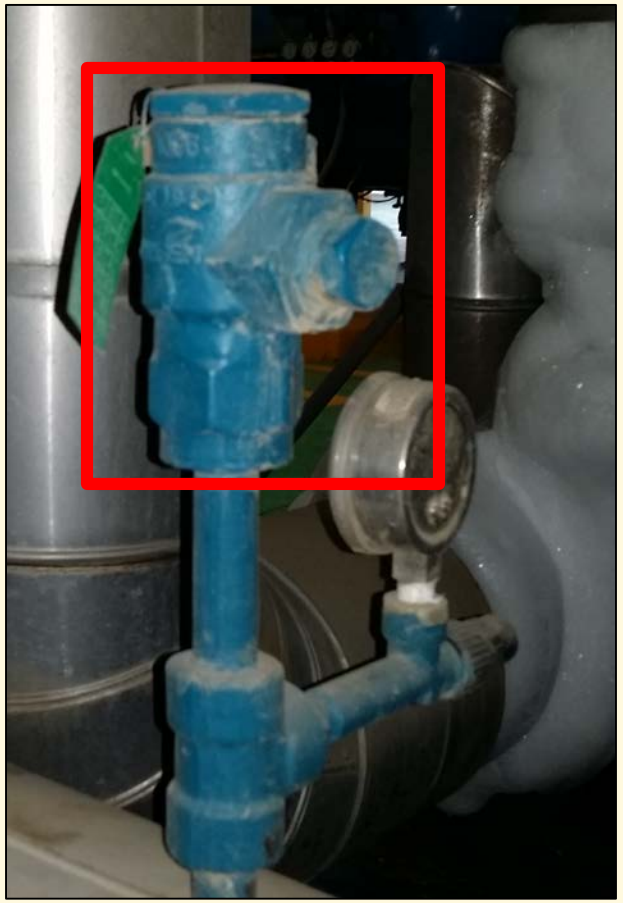
- **Piping [ANSI/IIAR 2-2014 §15.4]**



Relief Valve Installation

- **Piping [ANSI/IIAR 2-2014 §15.4]**





Relief Valve Replacement

Relief Valve Termination

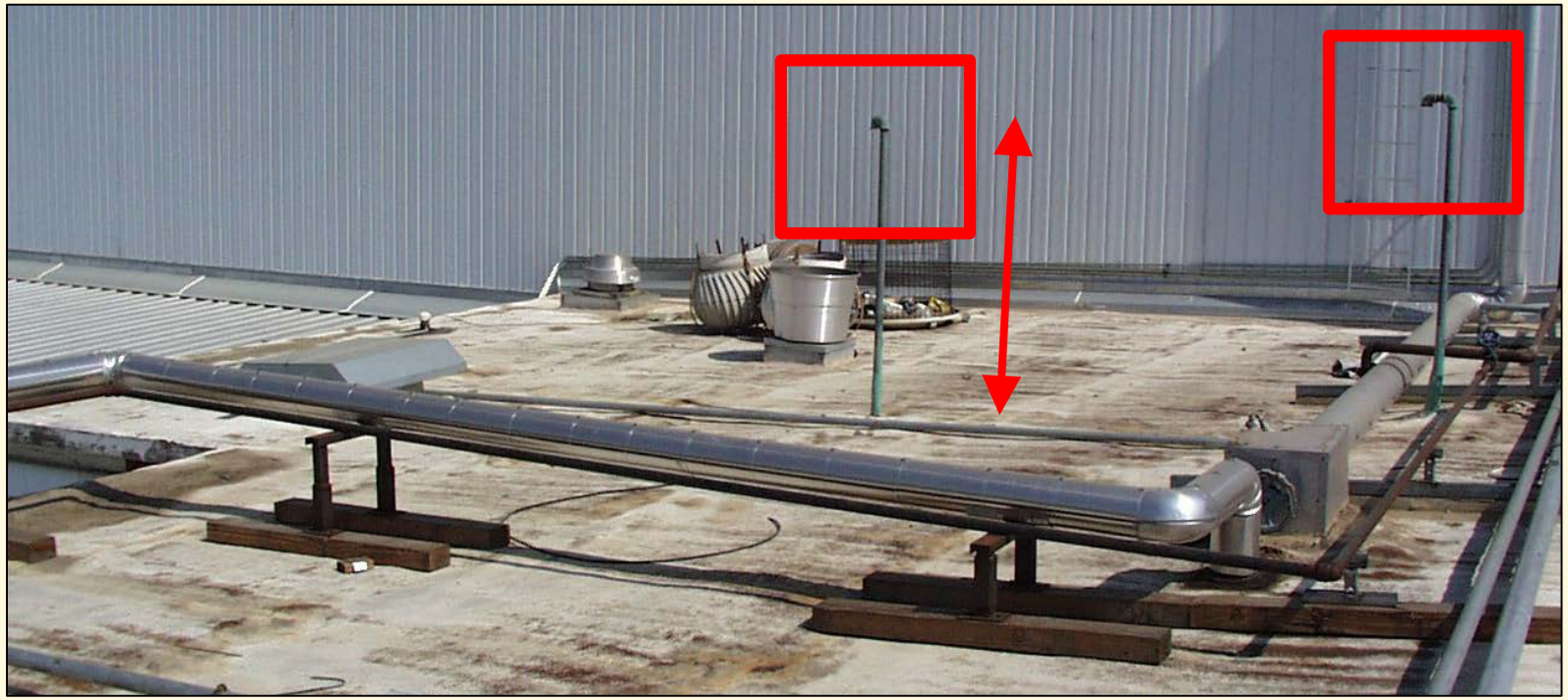
- **Ammonia Discharge [2013 CMC §1120.1]**

Relief Valve Termination

- **Atmospheric Discharge [ANSI/IIAR 2-2014 §15.5.1]**
  - Pipe sizing requirements [ANSI/IIAR 2-2014 §15.5.1.1.1]
  - Provision of draining moisture [ANSI/IIAR 2-2014 §15.5.1.6]
  - 20 ft from any window, ventilation intake, or personnel exit [ANSI/IIAR 2-2014 §15.5.1.2]
  - Not less than 15 feet above grade [ANSI/IIAR 2-2014 §15.5.1.2]
  - Not less than 7.25 feet above roof/platform [ANSI/IIAR 2-2014 §15.5.1.4, §15.5.1.5]
  - Arranged to avoid spraying ammonia on persons in the vicinity [ANSI/IIAR 2-2014 §15.5.1.5]

Relief Valve Termination

- **Atmospheric Discharge [ANSI/IIAR 2-2014 §15.5.1]**



Relief Valve Termination

Relief Valve Discharge Piping

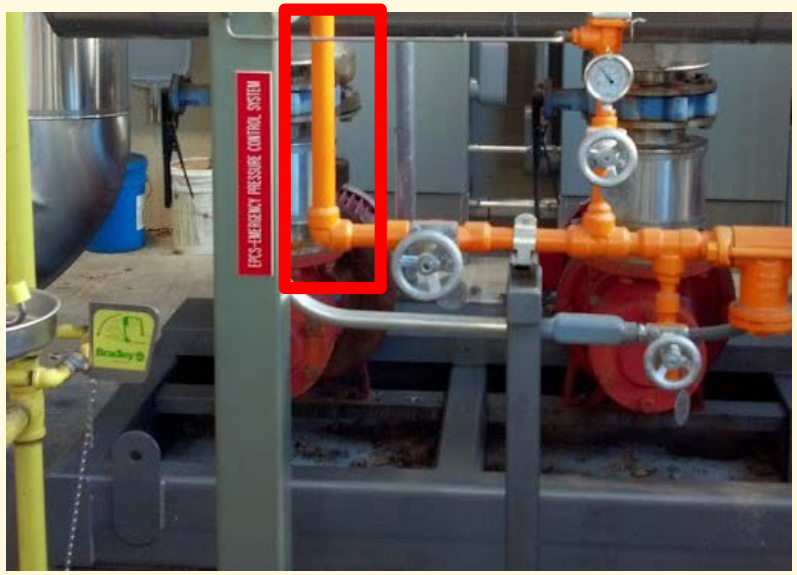
Relief Valve Discharge Piping

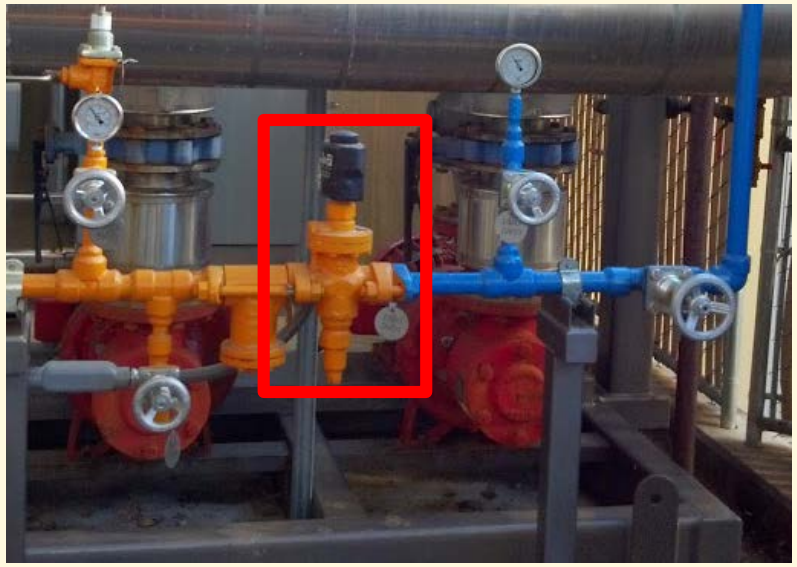
Relief Valve Discharge Piping

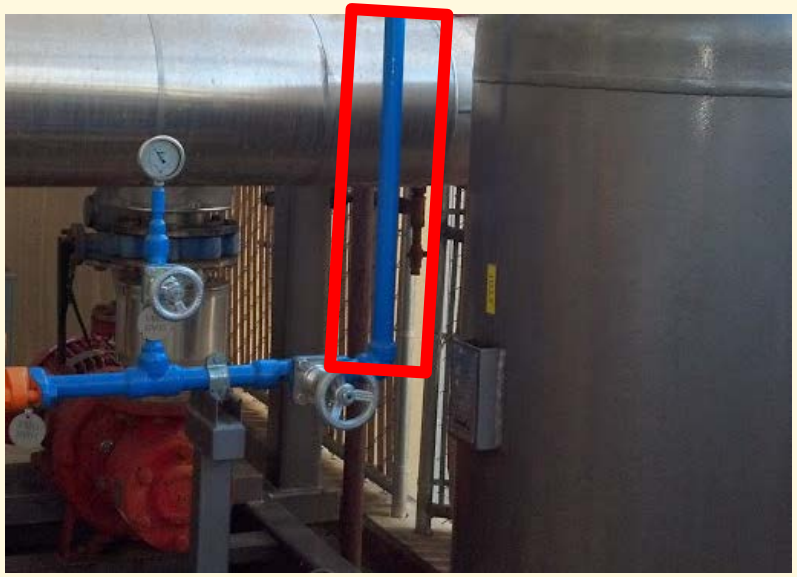
Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	¾	1	1¼	1½	2	2½	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
250	*2*	16.5	30.4	50.7	89.9	124	207	298	463	803	1268	1836
250	*3*	15.5	28.8	48.6	87.2	121	203	293	457	796	1260	1826
250	*4*	14.6	27.5	46.9	84.7	118	199	289	452	789	1251	1815
250	*5*	13.8	26.4	45.2	82.4	115	196	284	446	782	1243	1805
250	*6*	13.2	25.4	43.8	80.3	113	192	280	441	775	1234	1795
250	*8*	12.2	23.6	41.3	76.6	108	186	273	431	762	1219	1776
250	*10*	11.3	22.2	39.1	73.3	104	180	265	422	750	1203	1757
250	*15*	9.8	19.6	35	66.7	95.4	168	250	401	721	1167	1713
250	*20*	8.8	17.7	31.9	61.5	88.7	158	237	383	696	1135	1672
250	*25*	8	16.3	29.5	57.5	83.3	150	226	368	673	1104	1634
250	*30*	7.4	15.1	27.6	54.1	78.7	143	216	354	652	1076	1598
250	*40*	6.5	13.4	24.7	48.8	71.5	131	200	330	616	1026	1533
250	*60*	5.4	11.3	20.9	41.7	61.5	114	176	294	558	944	1423
250	*100*	4.3	8.9	16.6	33.6	49.9	93.7	146	248	479	826	1261
250	*160*	3.4	7.1	13.4	27.2	40.6	76.8	121	207	406	710	1096
250	*250*	2.7	5.8	10.8	22.1	33	62.9	99.2	171	340	602	937

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

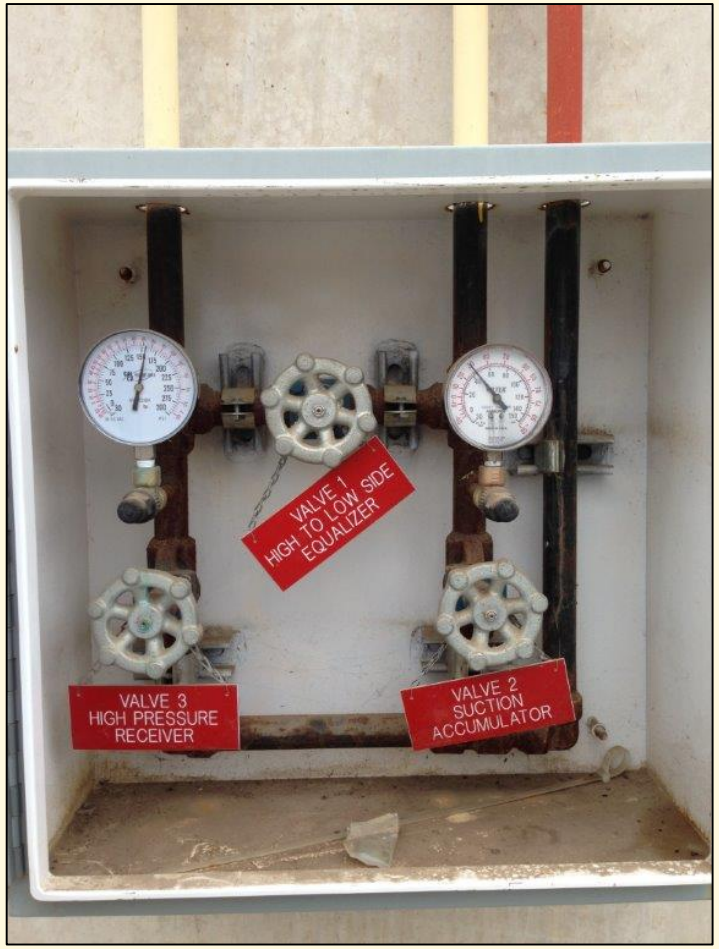
Emergency Pressure Control System

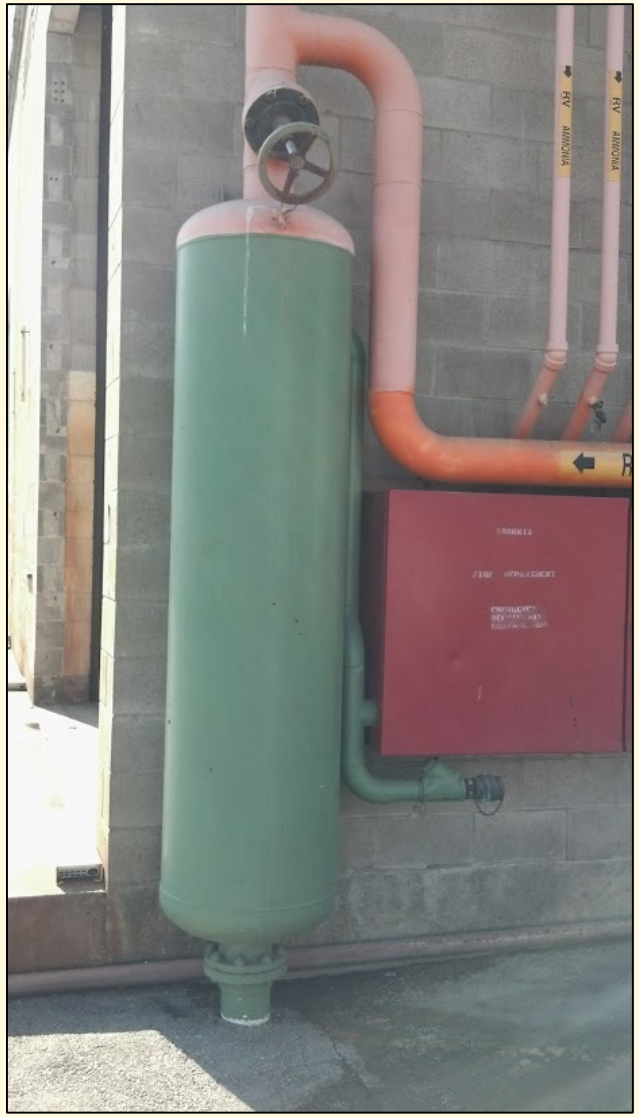




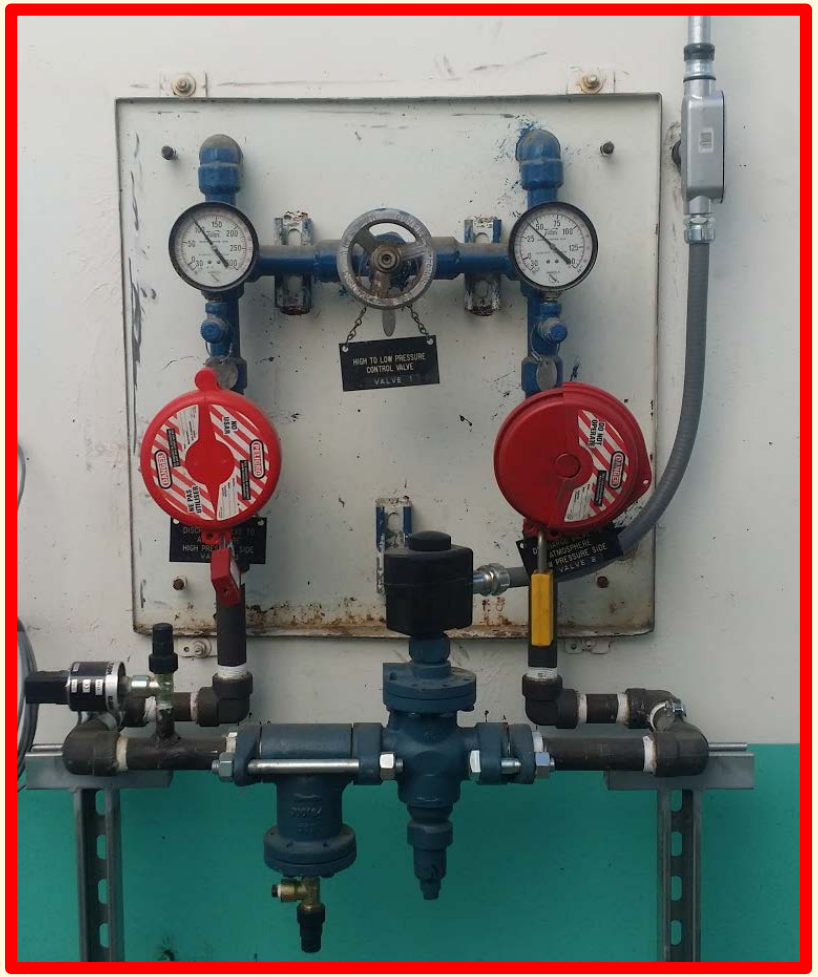


Emergency Control Box





Emergency Pressure Control System



Relief Vent Indicators / Vent Line Sensors

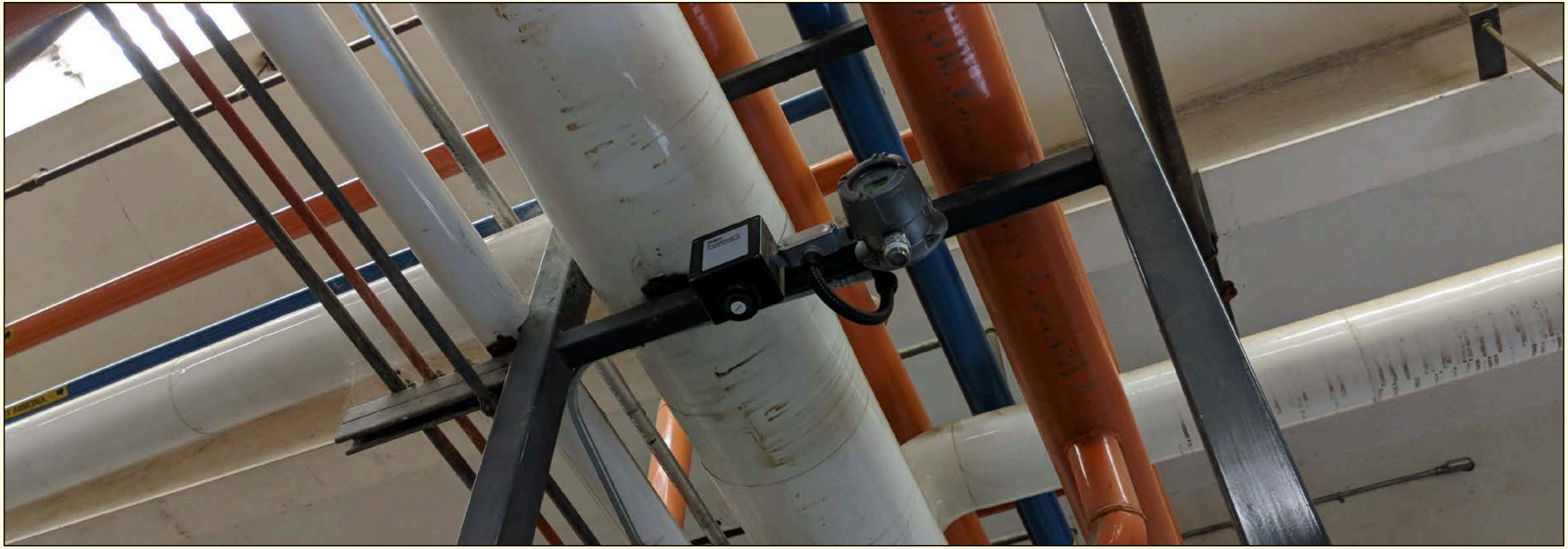
Ventilation

Installation

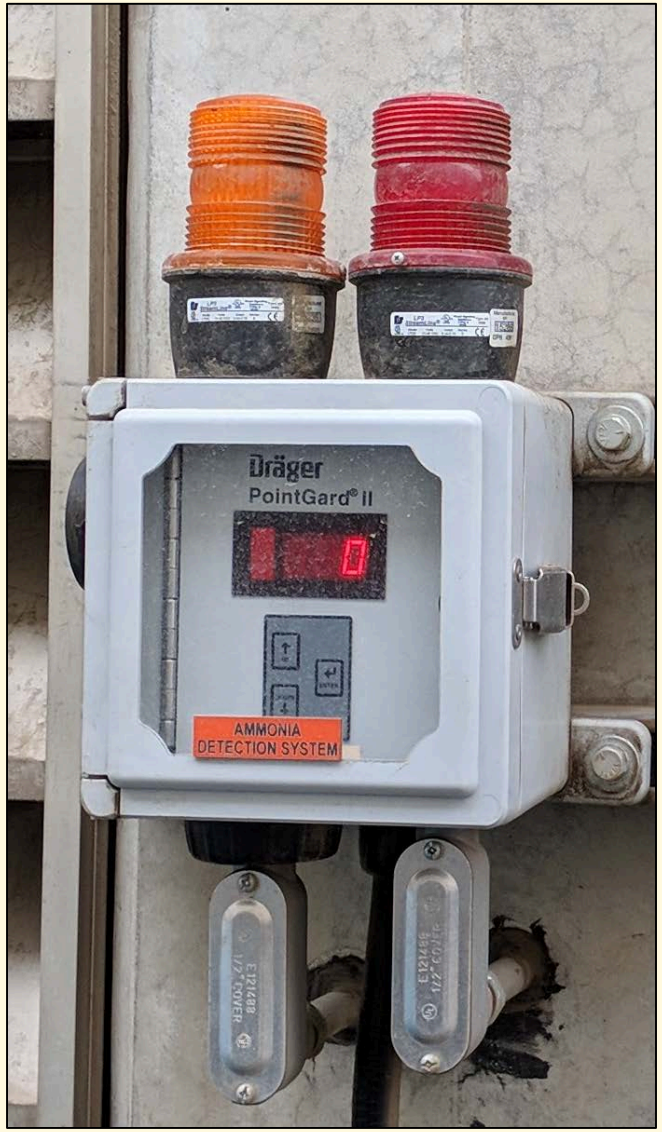
Ventilation

Control

Detection




HORN & STROBE
WARNING
AMMONIA MACHINERY ROOM REFRIGERATION & VENTILATION CONTROLS
Dräger PointGard® II
AMMONIA DETECTION SYSTEM
VENTILATION OK
VENTILATION FAIL
EMERGENCY SHUTDOWN
EMERGENCY VENTILATION


Dräger
PointGard® II
AMMONIA DETECTION SYSTEM


HORN & STROBE
WARNING
WHEN ALARMS ARE ACTIVATED AMMONIA HAS BEEN DETECTED:
1. LEAVE ROOM IMMEDIATELY.
2. DO NOT ENTER EXCEPT BY TRAINED & AUTHORIZED PERSONNEL.
3. DO NOT ENTER WITHOUT PERSONAL PROTECTIVE EQUIPMENT.

Machinery Rooms

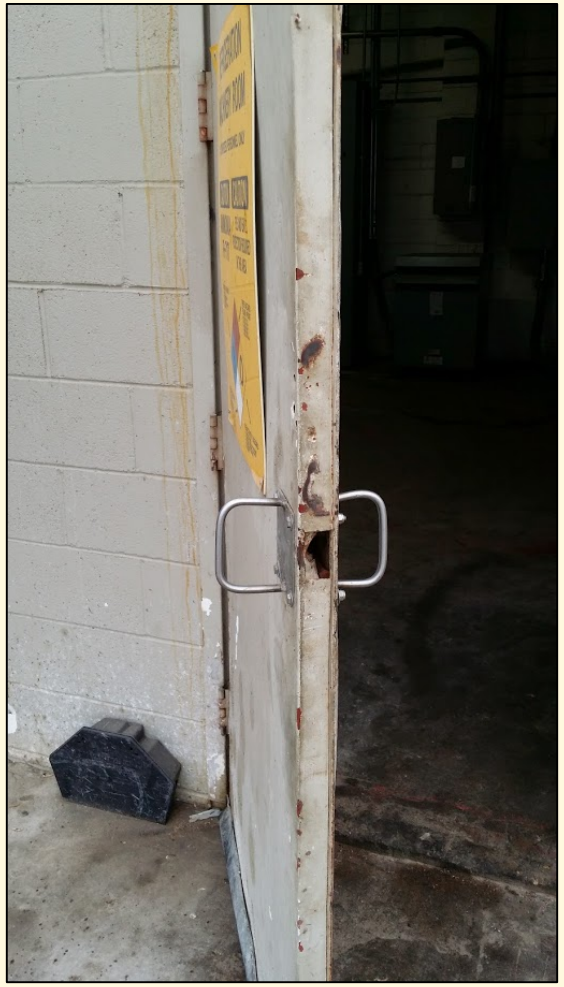
Machinery Room Access

Machinery Room Access

Machinery Room Access

Machinery Room Access

Machinery Room Doors



Question

- How many machinery room doors are required for a machinery room that is 40’ Long by 30’ wide?

a) 1
b) 2
c) >2
d) Up to the discretion of the building contractor


Dräger
Polytron TX
Adj


CAUTION
BATTERY CHARGING
STATION
NO SMOKING
OR OPEN FLAMES
CAUTION
EYE PROTECTION
MUST BE WORN
IN THIS AREA


Gas Sensor
NH3 SENSOR
EC-F9-0/100-N1
Manning
Systems, Inc.

Does your facility…..

Have ammonia detection?

Have machinery room ventilation?

Are they tied together?

Ammonia Detection – Level 1

1. At least one ammonia detector shall be provided in the room or area.
2. The detector shall activate an alarm that reports to a monitored location so that corrective action can be taken at an indicated concentration of **25 ppm** or higher.

[ANSI/IIAR 2-2014 §17.7.1]

Ammonia Detection – Level 2

1. Must meet all Level 1 Detection requirements
2. Audible and visual alarms shall be provided inside the room to warn that, when the alarm has activated, access to the room is restricted to authorized personnel and emergency responders.

[ANSI/IIAR 2-2014 §17.7.2]

Ammonia Detection – Level 3

1. Must meet all Level 2 Detection requirements
2. Additional audible and visual alarms shall be located outside of each entrance to the machinery room.
3. Upon activation of the alarm, control valves feeding liquid and hot gas to equipment in the affected area shall be closed. Refrigerant pumps, nonemergency fans, or other motors that are part of the ammonia refrigeration equipment in the room shall be de-energized.
4. Upon activation of the alarm, emergency exhaust systems, where required, shall be activated

[ANSI/IIAR 2-2014 §17.7.3]

Ammonia Detection – Machinery Rooms

- Variation of Level 3
- At least one ammonia detector inside the room
- The detector shall activate an alarm that reports to a monitored location so that corrective action can be taken at an indicated concentration of **25 ppm** or higher.
- Audible and visual alarms shall be provided inside the room to warn that access to the room is restricted to authorized personnel and emergency responders when the alarm has activated. Additional audible and visual alarms shall be located outside of each entrance to the machinery room.

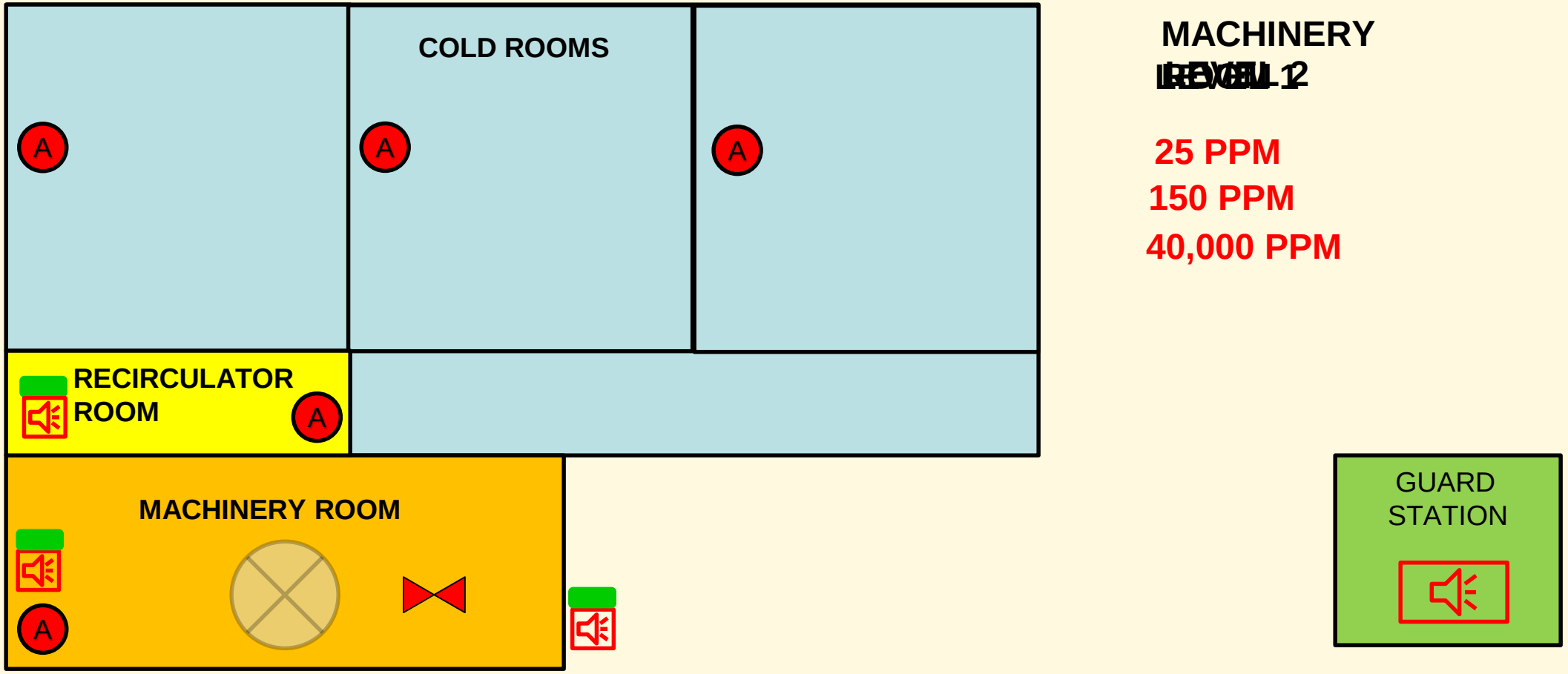
[ANSI/IIAR 2-2014 §6.13.1]

Ammonia Detection – Machinery Rooms

- Detection of ammonia concentrations less than **25 ppm** requires no alarm.
- Detection of **150 ppm** must activate emergency ventilation with manual reset required.
- Detection of **40,000 ppm** or vapor detector's upper limit must cause the following equipment to automatically de-energize:
  - Refrigerant compressors.
  - Refrigerant pumps.
  - Normally closed automatic refrigerant valves that are not part of an emergency control system

[ANSI/IIAR 2-2014 §6.13.2]

Ammonia Detection Example

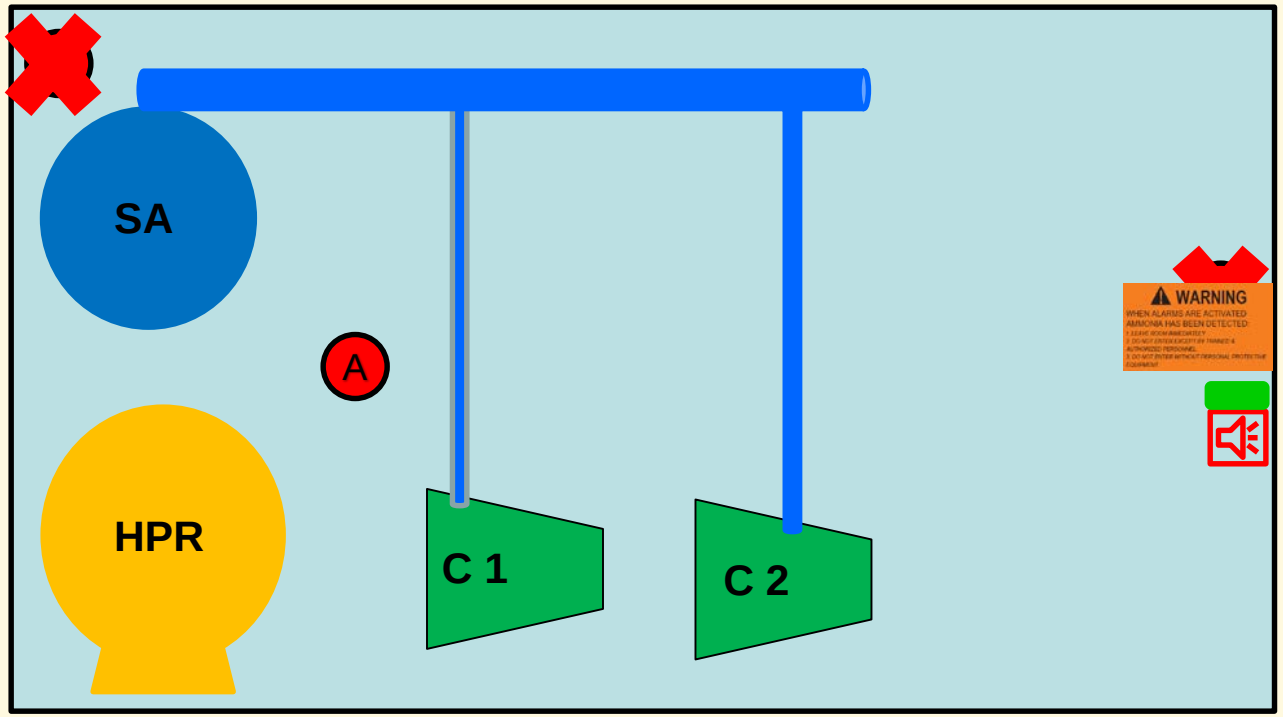


Ammonia Detection

Ammonia Detection

Ammonia Detection – Other Requirements

MACHINERY ROOM – ELEVATION VIEW



- LOCATED WHERE A LEAK IS MOST LIKELY TO OCCUR
- LOCATED WHERE THE SENSOR CAN BE SERVICED
- SIGNAGE
- TESTED PER MANUFACTURER'S RECOMMENDATION
- DEDICATED POWER CIRCUIT
- FAILURE OF DETECTION

Rel. humidity, min./max. 15/95 %

Ammonia Detection – Other Requirements

- A means shall be provided for monitoring the concentration of an ammonia release in the event of a power failure.

[ANSI/IIAR 2-2014 §16.1.4]

Machinery Room Ventilation

1. Emergency Ventilation
2. Temperature Control

Are all machinery rooms required to have ventilation?

- Machinery room ventilation is required per IIAR 2 (1974, 1978, 1984, 1999, 2008, 2014)


AMERICAN NATIONAL STANDARD
FOR
EQUIPMENT, DESIGN, AND
INSTALLATION
OF AMMONIA MECHANICAL
REFRIGERATION SYSTEMS

ANSI/IIAR 74-2 - 1978

iiar

Sponsor

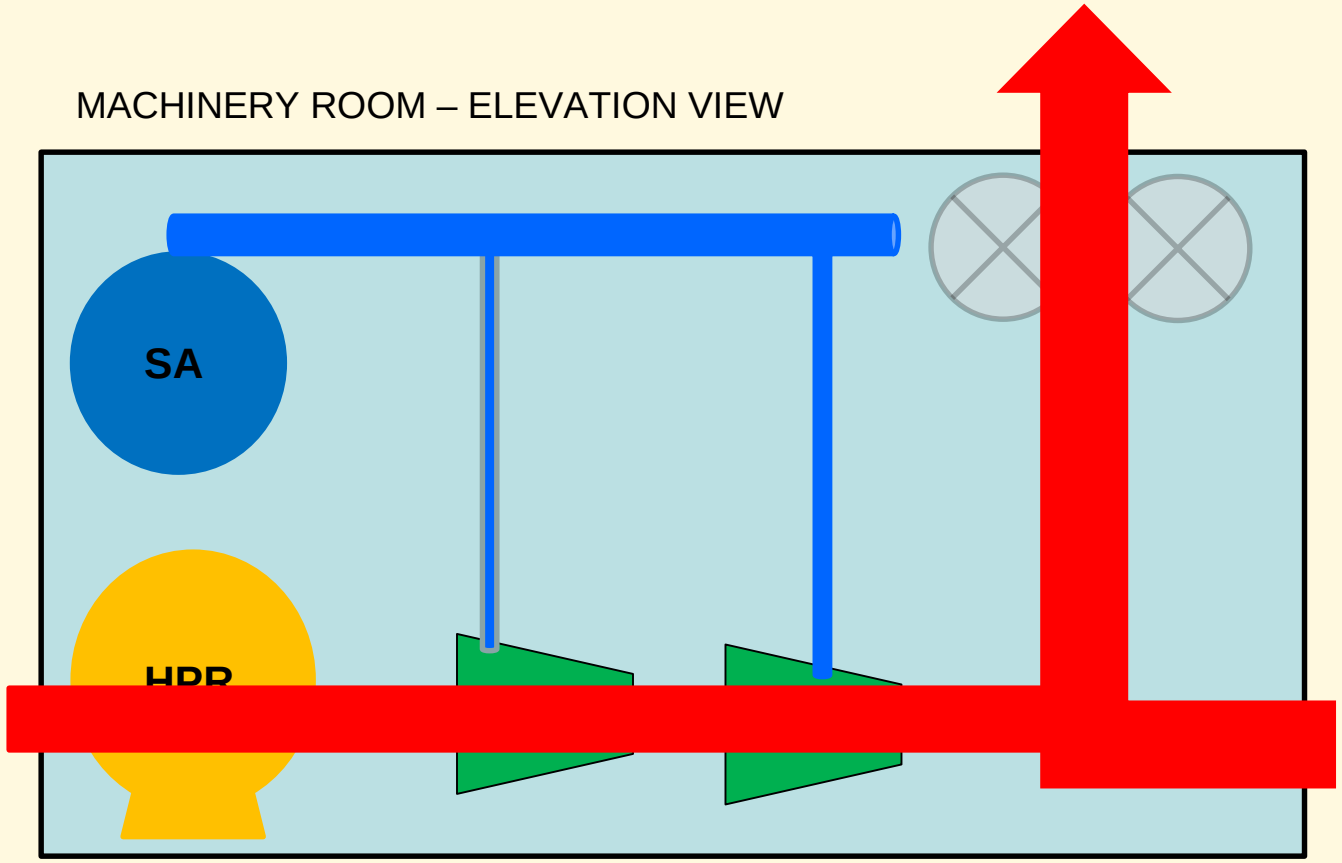
INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION

Approved by
The American National Standards Institute
March 16, 1978

COPYRIGHT 1974

The room shall be provided with an independent mechanical ventilation system actuated automatically by vapor detector(s) when concentration of ammonia in the room exceeds 40,000 parts per million…[ANSI/IIAR 74-2 - 1978 §4.3.3.2]

Machinery Room Ventilation



- **EMERGENCY VENTILATION ACTIVATED WHEN 150 PPM OF AMMONIA IS DETECTED**
- **TEMPERATURE CONTROL VENTILATION ACTIVATED BEFORE 104°F**
- **MUST NOT SHORT CIRCUIT**
- **CLEARLY IDENTIFIED AUTO/ON SWITCH OUTSIDE PRIMARY ENTRANACE**
- **POWERED INDEPENDENTLY OF EQUIPMENT AND SHUT DOWN CONTROLS**
- **POWER FAILURE TO SIGNAL A MONITORED LOCATION**

GUARD STATION

Exhaust Fan Requirements

- Ducts must serve only the machinery room
- Must exhaust outdoors no fewer than 20 ft from a property line
- Minimum discharge velocity of 2,500 ft/min
- Fan blades must be nonsparking
- Fans must be of the totally enclosed type

Inlet Air Requirements

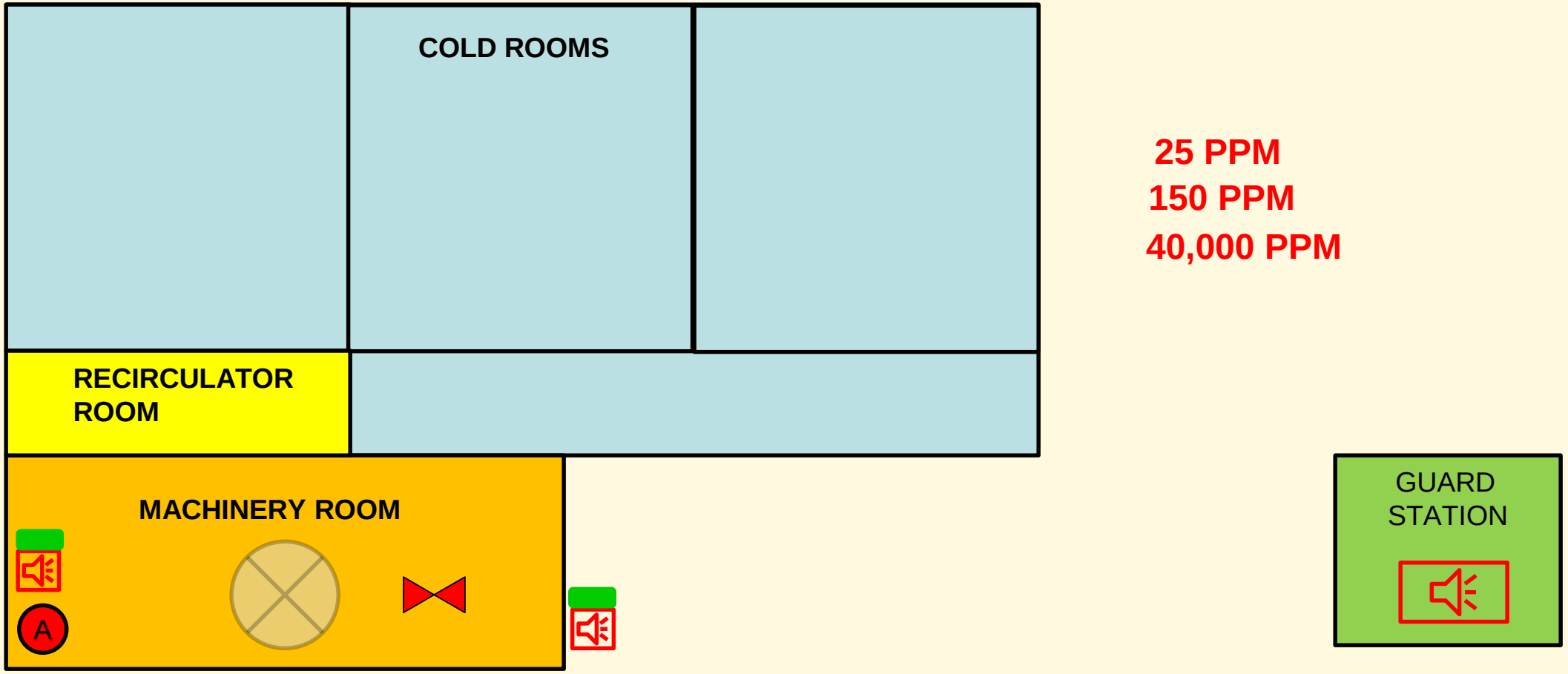
- Outside make-up air shall be provided and must maintain a negative pressure in the room. Pressure shall not exceed 0.25 inches water column
- Make-up air positioned to avoid short-circuiting
- Make-up air openings shall be covered with not less than ¼” mesh
- Intakes shall draw uncontaminated air
- Intakes for make-up shall serve only the machinery room
- Motorized louvers or dampers, where utilized, shall fail open
- Where direct opening are not provided, make-up air shall be provided by fans

Ventilation Additional Requirements

- **Testing Schedule.** A schedule for testing ammonia detectors and alarms shall be established based on manufacturers' recommendations, unless modified based on documented experience.
- **Minimum Test Frequency.** Where manufacturers' recommendations are not provided, ammonia detectors and alarms shall be tested at least annually.

[ANSI/IIAR 2-2014 §17.3]

Emergency Ventilation and Ammonia Detection




REFRIGERATION
AMMONIA
EMERGENCY STOP
EMERGENCY MECHANICAL ROOM VENTILATION
EXHAUST FAN FLOW
CENTRAL MECHANICAL ROOM VENTILATION
HAND
OFF
AUTO
SUCTION ACCUMULATOR HIGH LEVEL
EXHAUST FAN NO FLOW
ENGINE ROOM AMMONIA
ALARM SILENCE
ALARM RESET


EMERGENCY REFRIGERATION
SWITCH BREAK GLASS
EMERGENCY VENTILATION
SWITCH BREAK GLASS
telemecanique


Safety Relief Valve
Type
Serial
Set Pressure
psig
Air Capacity
scfm
Inlet
Outlet
Size
Parker

Machinery Room Storage

Machinery Room Open Flames

Eyewash and Safety Showers

Pipe


ASME SA53/SA106 GR.B/API 5L B PSL1/NACE MR0175/
x 21"H.5871H/2500
NDE/B.BLG 892/3.63 LBS/FT/INDIA

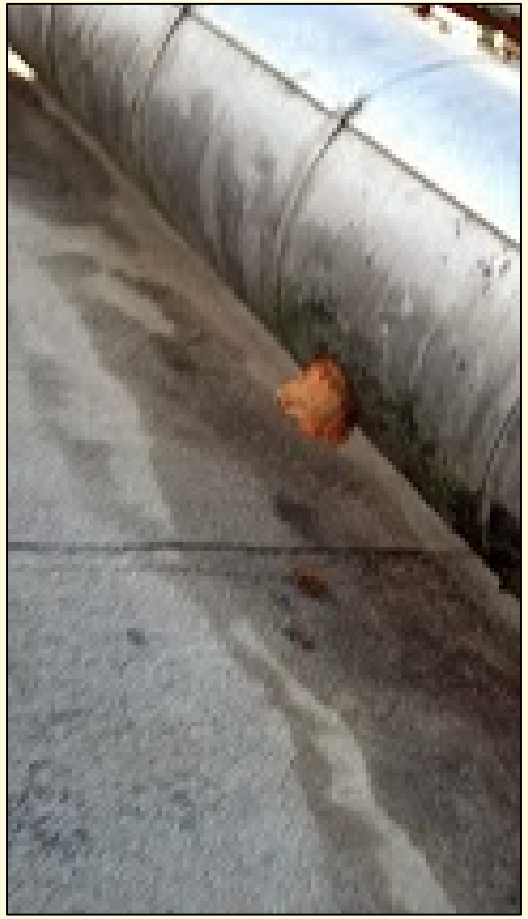
Pipe

Insulation

Insulation

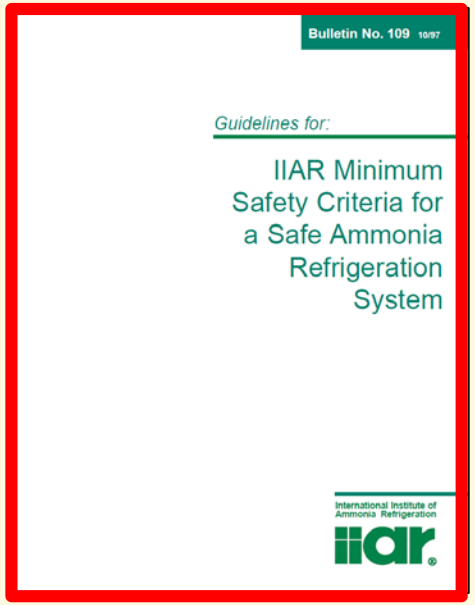
Insulation

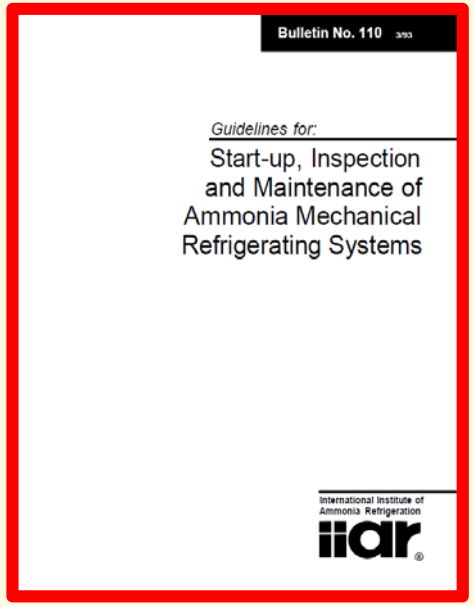
Insulation

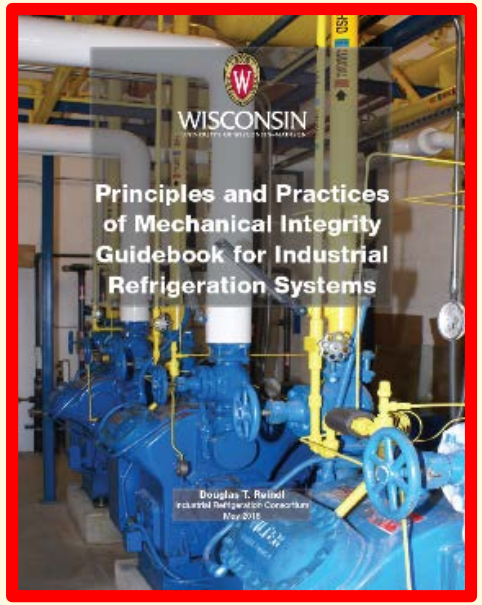


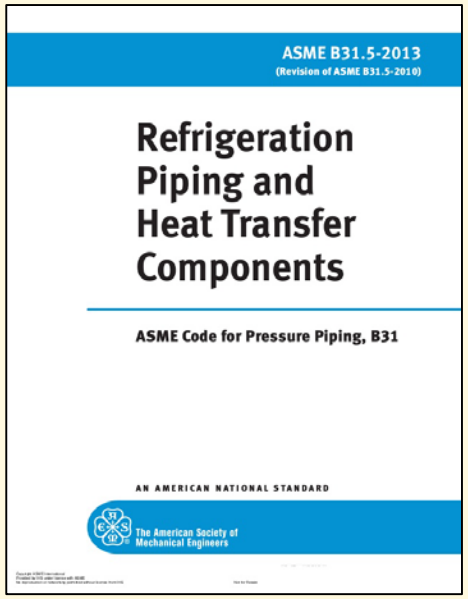
Pipe Wall Thickness

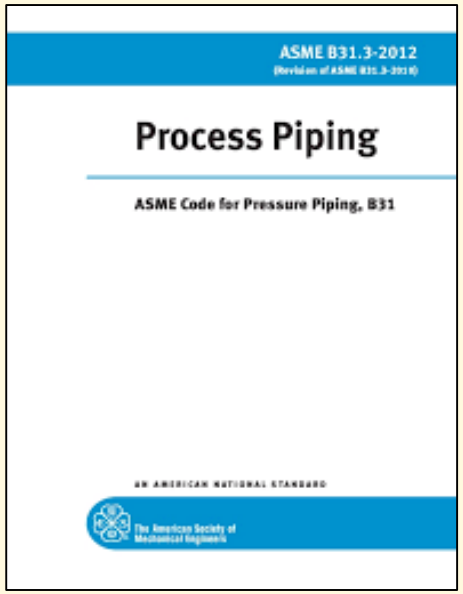
Key RAGAGEP documents











IRC MI Guidebook

Table 4-5: Piping mechanical integrity action summary (adapted from Section 11.1.5 of RP 574).

Nominal Size (in)	Sch	Outside Diameter (in)	Nom. Wall Thickness (in)	Min Nom. Wall Thickness (in)	Wall thickness deviation from nominal (%)	Alert Wall Thickness (in)	Wall thickness deviation from nominal (%)	Replace Wall Thickness (in)	Wall thickness deviation from nominal (%)
1/2"	80	0.840	0.147	0.129	(12.5)	0.080	(45.6)	0.044	(70.0)
	160		0.294	0.257	(12.5)	0.080	(72.8)	0.080	(72.8)
3/4"	80	1.050	0.154	0.135	(12.5)	0.080	(48.1)	0.046	(70.0)
	160		0.308	0.270	(12.5)	0.080	(74.0)	0.080	(74.0)
1"	80	1.315	0.179	0.157	(12.5)	0.080	(55.3)	0.054	(70.0)
1-1/4"	80	1.660	0.191	0.167	(12.5)	0.080	(58.1)	0.057	(70.0)
1-1/2"	80	0.200	0.200	0.175	(12.5)	0.090	(55.0)	0.060	(70.0)
2"	40	2.375	0.154	0.135	(12.5)	0.100	(35.1)	0.046	(70.0)
	80		0.218	0.191	(12.5)	0.100	(54.1)	0.065	(70.0)
2-1/2"	40	2.875	0.203	0.178	(12.5)	0.100	(50.7)	0.061	(70.0)
3"	40	3.500	0.216	0.189	(12.5)	0.110	(49.1)	0.065	(70.0)
4"	40	4.500	0.237	0.207	(12.5)	0.120	(49.4)	0.071	(70.0)
5"	40	5.563	0.258	0.226	(12.5)	0.120	(53.5)	0.077	(70.0)
6"	40	6.325	0.280	0.245	(12.5)	0.130	(53.6)	0.084	(70.0)
8"	40	8.625	0.322	0.282	(12.5)	0.130	(59.6)	Requires evaluation of minimum thickess to satisfy piping design pressure	
10"	40	10.75	0.365	0.319	(12.5)	0.136	(62.6)		
12"	ST	12.75	0.375	0.328	(12.5)	0.162	(56.9)		
14"	30	14.0	0.375	0.328	(12.5)	0.178	(52.6)		
16"	30	16.0	0.375	0.328	(12.5)	0.203	(45.9)		
18"	ST	18.0	0.375	0.328	(12.5)	0.228	(39.1)		

Table 4-6: Piping inspection concern level summary for given values of wall thickness, *t*.

Level	Criteria	Flag	Action Required/Comments	Reference
1	$t \leq 0.3 * t_{nom}$		Piping at this wall thickness must be repaired or replaced unless an engineering analysis shows it is fit for continued operation. If the engineering analysis concludes that the piping is fit for continued operation, all active surface corrosion must be arrested and the surface coating restored without delay.	Gerber et al (1992)
2	$0.3 * t_{nom} \leq t < t_{alert}$		Piping below the alert wall thickness requires a more detailed engineering analysis to determine t_{min} for the portion of the piping system in question as a basis for evaluating its fitness for continued operation. If the measured wall thickness, t, at any location is less than the minimum allowable wall thickness ($t < t_{min}$), the pipe is not fit for continued operation and must be replaced promptly. If the pipe wall is above the minimum wall thickness, all active corrosion must be arrested/converted and the surface restored as soon as possible.	API RP 574 (2009) & ASME B31.5 (2013)
3	$t_{alert} \leq t < 0.875 * t_{nom}$		If the measured wall thickness, t, is less than nominal minus the mill tolerance but greater than t_{alert}, the piping can continue operation. As the wall thickness approaches t_{alert}, consider increased inspection frequency.	API RP 574 (2009) & ASME B31.5 (2013)
4	$t \geq 0.875 * t_{nom}$		Piping at this wall thickness is fit for continued operation. Ensure that any active surface corrosion is arrested and the surface restored in a timely manner.	Original design per ASME B31.5 (2013)

Pipe Supports

Pipe Supports

Pipe Supports

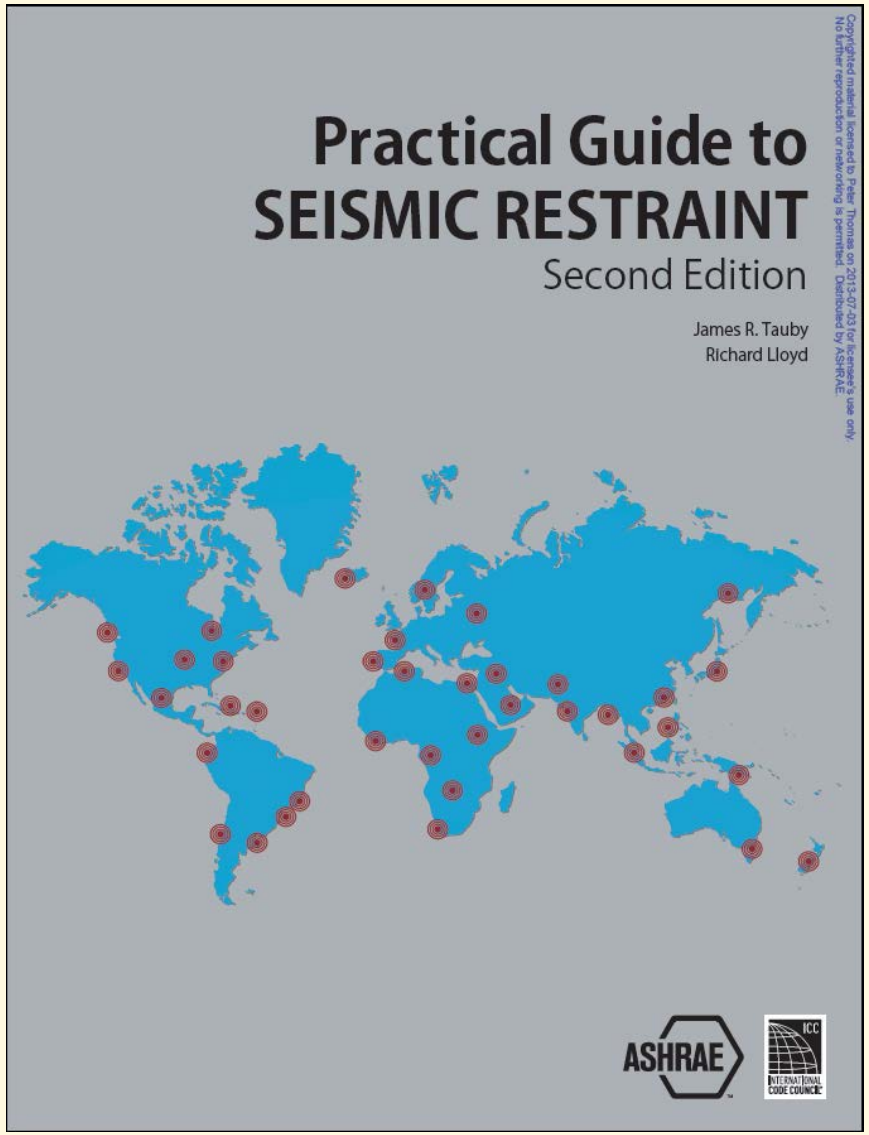
Pipe Supports

- ANSI/IIAR 2-2014 Appendix F

Nominal Pipe Size	Maximum Span	Minimum Rod Diameter
Up to 1	7	1/8
1-¼ - 1-1/2	9	3/8
2	10	3/8
2-1/2	10	1/2
3	12	1/2
4	14	5/8
5	16	5/8
6	17	3/4
8	19	7/8
10	22	7/8
12	23	7/8

Equipment Anchors

Supports and Anchorage



Anchorage

Trapeze Supports

Safe Access

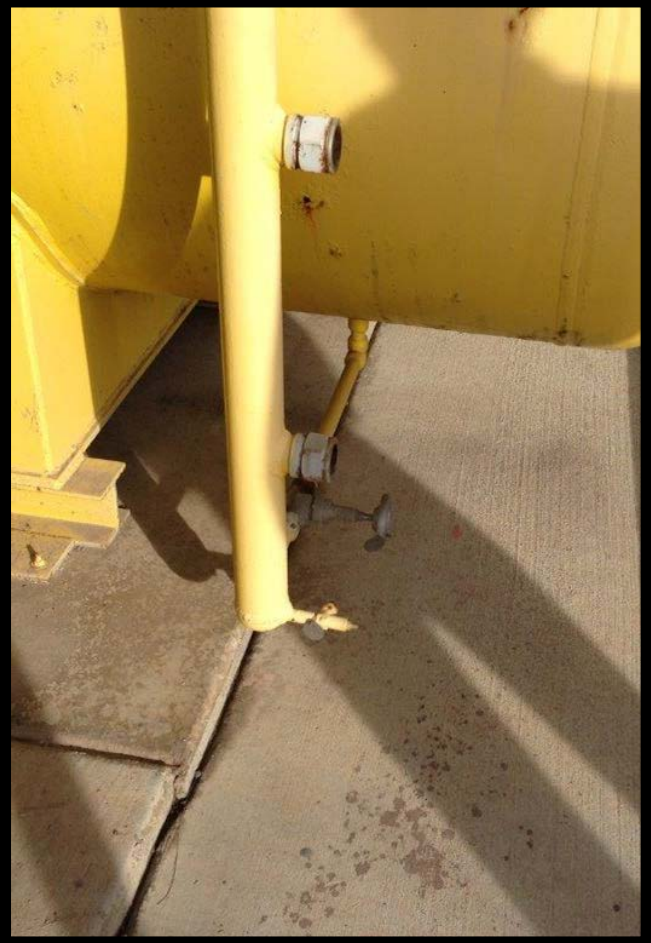
Safe Access

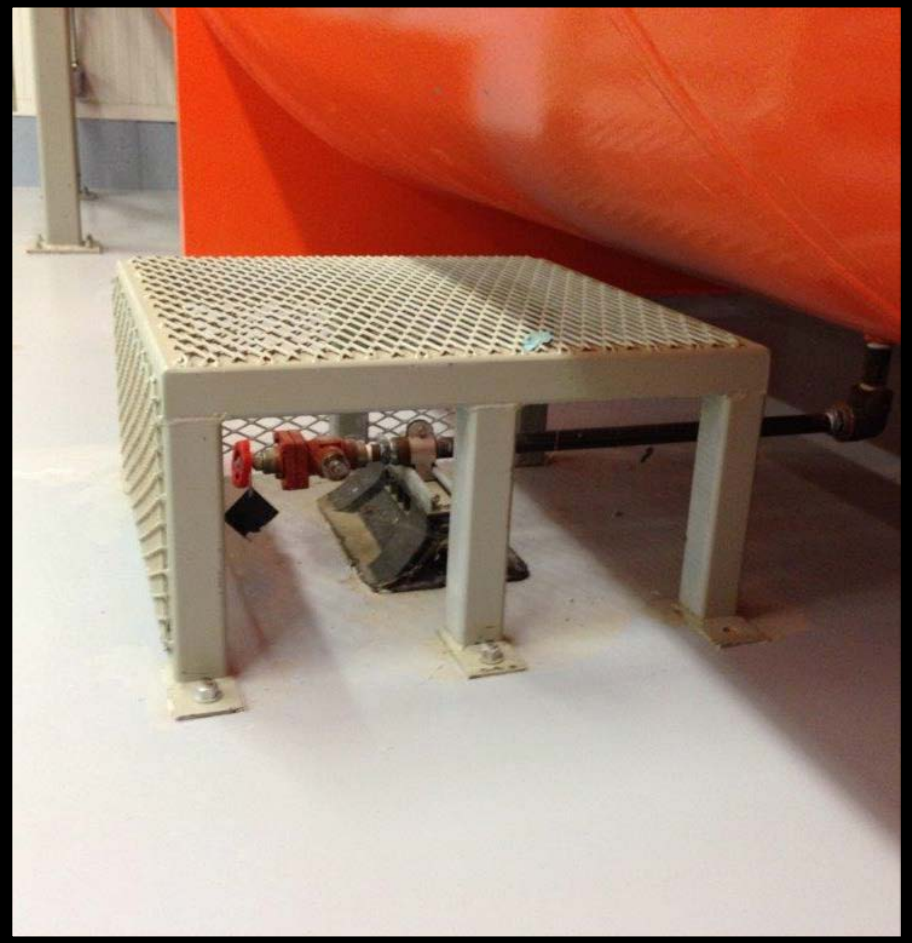
Service Provision

- **Maintenance Accommodation**
  - Equipment shall be accessible for maintenance, as required by the Mechanical Code. [ANSI/IIAR 2-2014 §5.12.1]
  - Shell and Tube Condenser [ANSI/IIAR 2-2014 §10.4.4]
  - Plate Heat Exchanger Condenser [ANSI/IIAR 2-2014 §10.5.4]
  - Double-Pipe Condenser [ANSI/IIAR 2-2014 §10.6.4.1]
  - Shell and Tube Evaporator [ANSI/IIAR 2-2014 §11.3.1.4, ANSI/IIAR 2-2014 §11.3.2.4]
  - Plate Heat Exchanger Evaporator [ANSI/IIAR 2-2014 §11.4.4]
  - Scraped Surface Heat Exchanger [ANSI/IIAR 2-2014 §11.5.4]
  - Pressure Vessels [ANSI/IIAR 2-2014 §12.6.1]

Safe Access

- **Valves**
  - Stop valves shall be readily accessible from the machinery room floor or a level platform [2013 CMC §1112.3]
  - Manually operated valves that are inaccessible from floor level shall be operable from portable platforms, fixed platforms, ladders, or shall be chain operated. [ANSI/IIAR 2-2014 §6.3.3.1]
  - Manually operated isolation valves identified as being part of the system emergency shutdown procedure shall be directly operable from the floor or chain operated from a permanent work surface. [ANSI/IIAR 2-2014 §6.3.3.2, §13.3.7]
  - Relief device arrangements shall be configured to allow access for inspection, maintenance, and repair. [ANSI/IIAR 2-2014 §15.2.3]
  - Similar requirement dating back to 1978



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SERIAL NO
MADE IN USA

Questions?

pthomas@resourcecompliance.com