Introduction to Ammonia Refrigeration

Uriah Donaldson, OHST – Process Safety Consultant

Overview of this Talk

1. Benefits of Ammonia Refrigeration
2. The Importance of Safety for Ammonia Refrigeration

RESOURCE COMPLIANCE

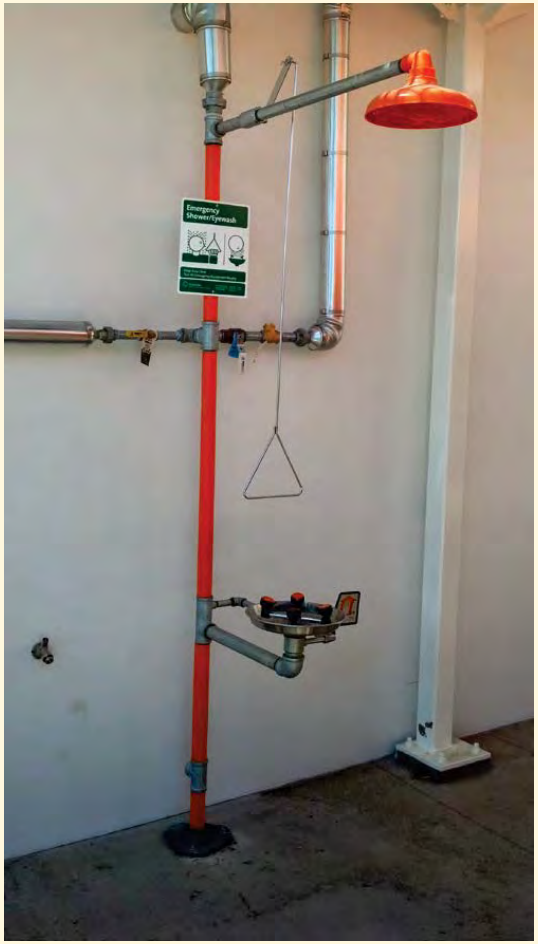
Providing Solutions. Simplifying Regulation.

The Benefits of Ammonia Refrigeration

RESOURCE COMPLIANCE

1. Naturally occurring compound (NH3)
2. If released, it naturally breaks down into its basic elements
3. Not ozone depleting (GWP=0)
4. Vapor density is less than air
5. Natural pungent, self-alarming odor
6. Does not mix with oil
7. Less expensive than synthetic refrigerants
8. Ammonia is a high capacity refrigerant
9. Ammonia is a widely used refrigerant with support from engineers, service technicians, and safety experts

RESOURCE COMPLIANCE



RESOURCE COMPLIANCE

Providing Solutions. Simplifying Regulation.

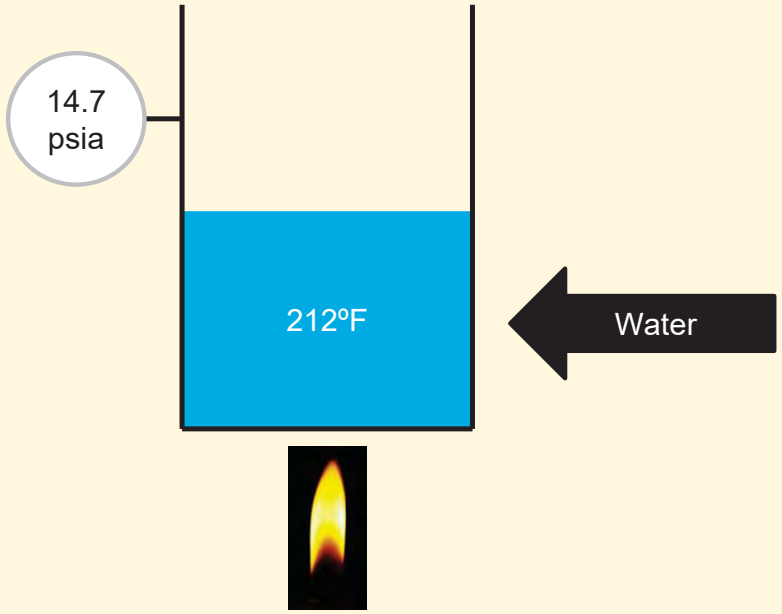
The Importance of Safety for Ammonia Refrigeration

Introduction to Ammonia Refrigeration

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

Refrigeration

State 1



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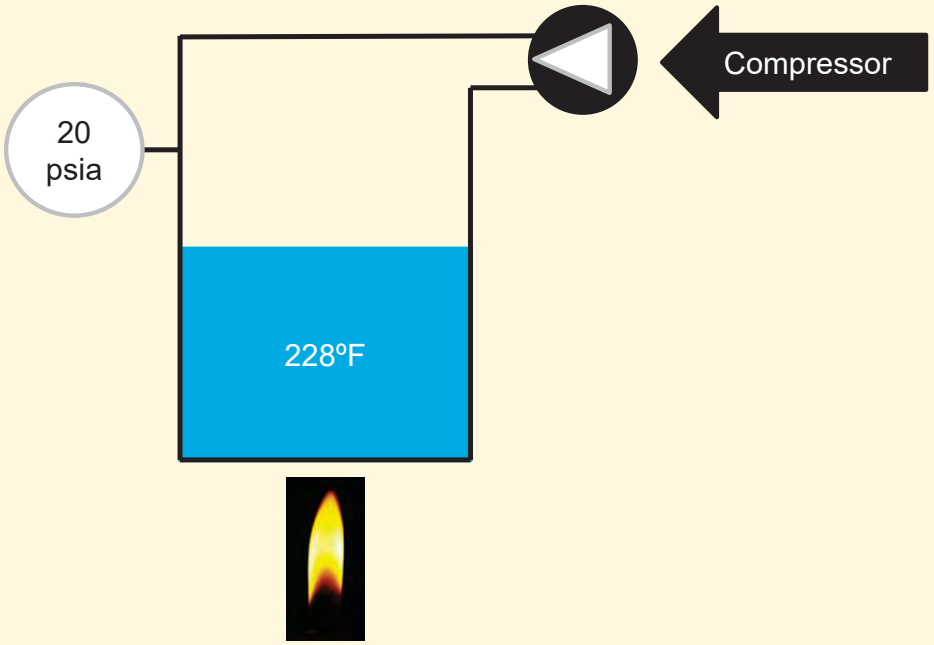

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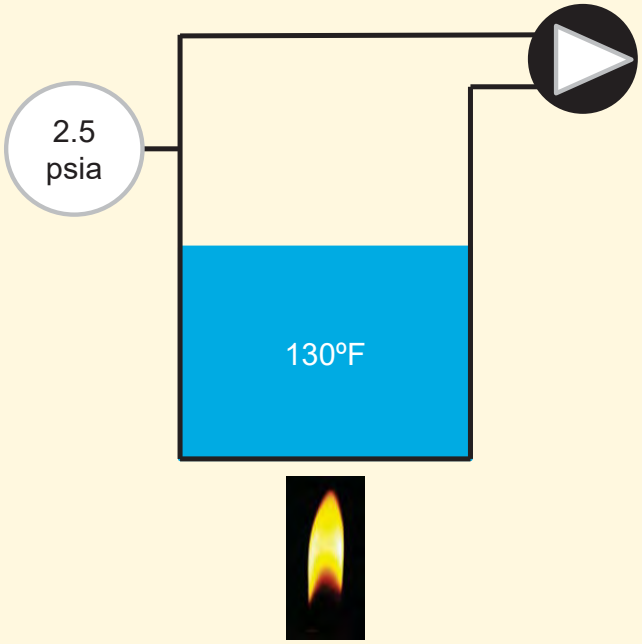

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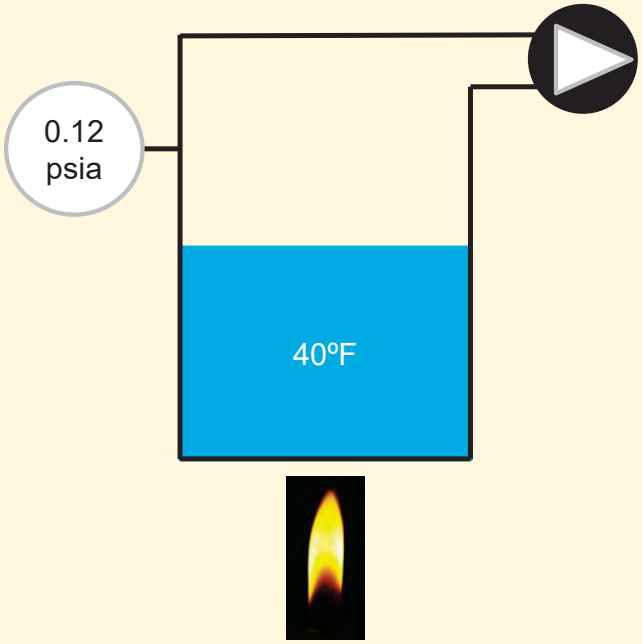
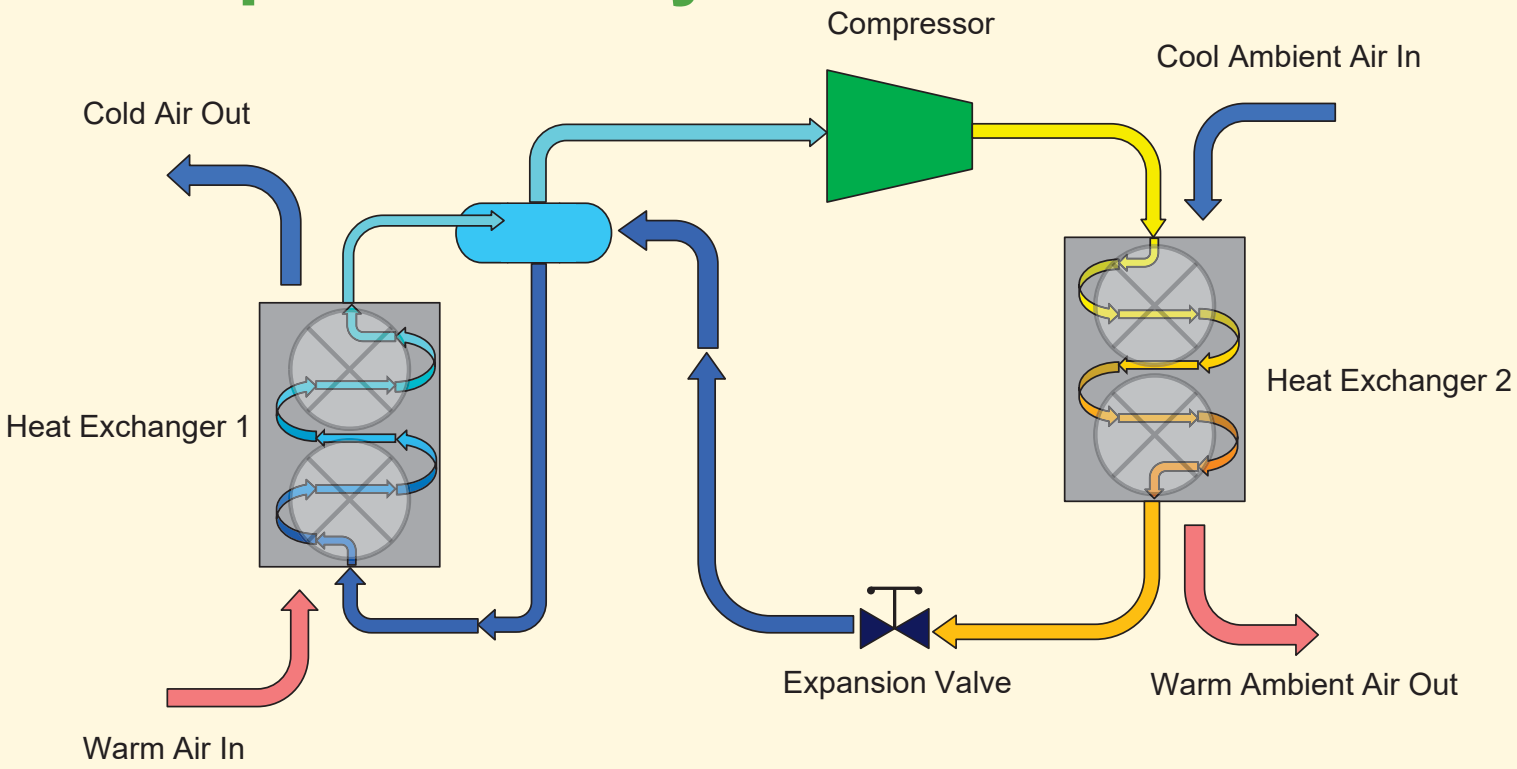
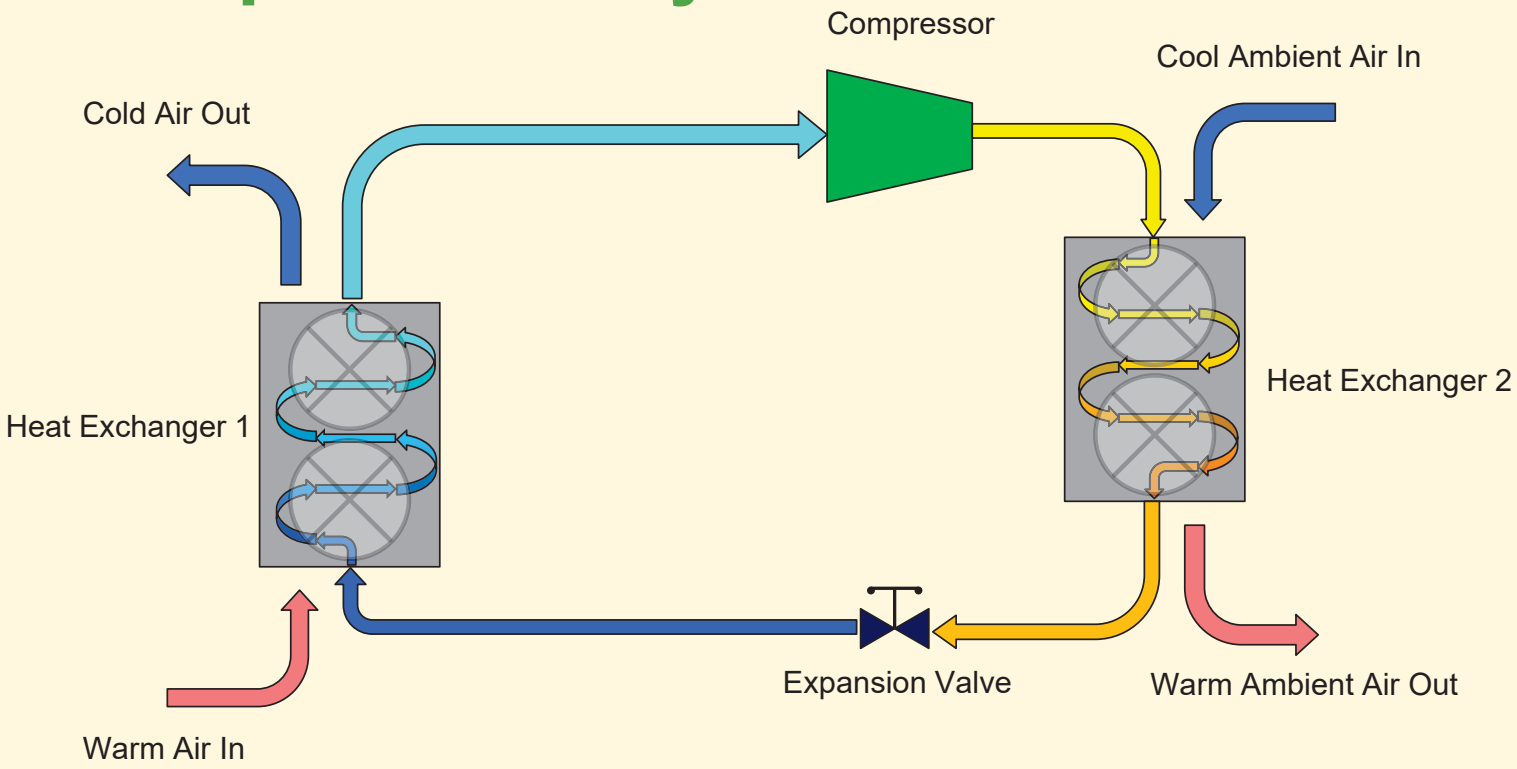


Vapor Compression Cycle



Vapor Compression Cycle



Refrigeration

- Manipulation of the of the pressure of **Substance 1** in order to reduce the temperature of **Substance 1** for the purpose of achieving a desired lower temperature in **Substance 2**.
- *Substance 1* = Refrigerant
- *Substance 2* = Air, water, grapes, wine, apples, beef, wine, oranges, peaches, chicken, ice…..

Heat Transfer Equation - Sensible

$$Q = M \times C \times \Delta T$$

- Where:
  - Q = heat required (BTU)
  - M = mass of substance (lb)
  - C = specific heat capacity (BTU/lb-ºF)
  - $\Delta T = T_2 - T_1$ = Difference between the starting temperature and the ending temperature (ºF)

Example 1

- Determine the BTUs required to warm 2 lb of water from 40ºF to 70ºF.

$$Q = M \times C \times \Delta T$$

$$Q = 2lb \times 1\frac{BTU}{lb \cdot ºF} \times (70ºF - 40ºF)$$

$$\underline{\boldsymbol{Q = 60\ BTU}}$$

Example 2

- Determine the BTUs required to warm 2 lb of iron from 40ºF to 70ºF.

$$Q = M \times C \times \Delta T$$

$$Q = 2lb \times 0.118 \frac{BTU}{lb \cdot ºF} \times (70ºF - 40ºF)$$

$$\underline{\boldsymbol{Q = 7.08\ BTU}}$$

Heat Transfer Equation - Latent

$$Q = M \times h_L$$

- Where:
  - Q = heat required (BTU)
  - M = mass of substance (lb)
  - h_L = specific enthalpy (BTU/lb)

Example 3

- Determine the BTUs required to boil 2 lb of 212ºF water into steam.

$$Q = M \times h_L$$

$$Q = 2lb \times 970 \frac{BTU}{lb}$$

$$\underline{\boldsymbol{Q = 1,940\ BTU}}$$

Heat Transfer Equation - Combined

$$Q_{Total} = Q_{Sensible} + Q_{Latent}$$

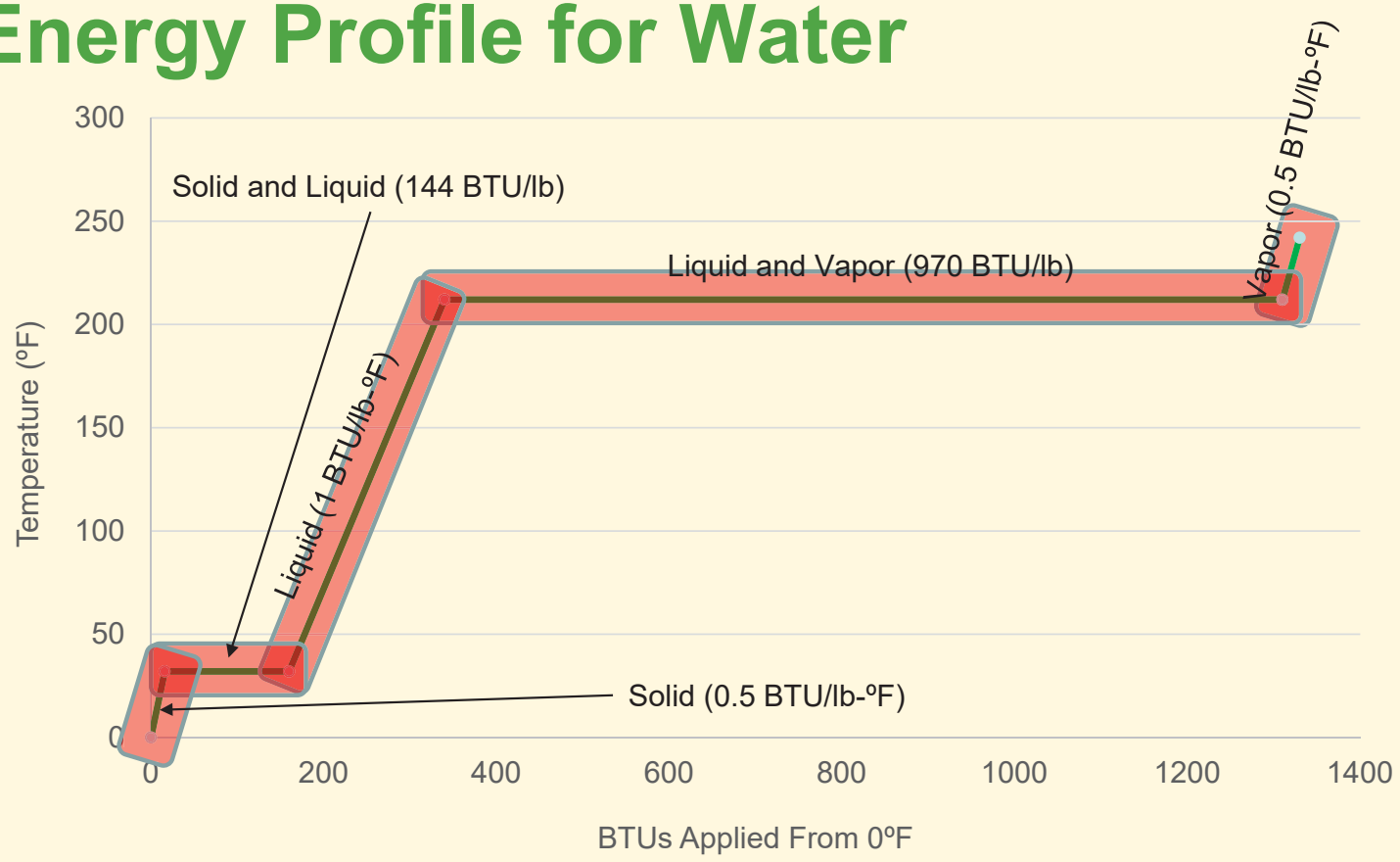
- Where:
  - Q_{Total} = total heat required (BTU)
  - $Q_{Sensible}$ = sensible heat (BTU)
  - Q_{Latent} = latent heat (BTU)

Example 4

- Determine the BTUs required to boil 2 lb of 40ºF water into steam.

$$Q_{Total} = Q_{Sensible} + Q_{Latent}$$
$$Q_{Sensible} = M \times C \times \Delta T$$
$$Q_{Latent} = M \times h_L$$
$$Q_{Total} = (M \times C \times \Delta T) + (M \times h_L)$$
$$Q_{Total} = \left(2lb \times 1\frac{BTU}{lb \cdot ºF} \times (212ºF - 40ºF)\right) + (2lb \times 970\frac{BTU}{lb})$$
$$\underline{\boldsymbol{Q_{Total} = 2,284BTU}}$$

Heat Energy Profile for Water



Example 5

- Determine the BTUs required to freeze 2,000 lb (1 ton) of 32ºF water into ice.

$$Q = M \times h_L$$

$$Q = 2{,}000lb \times 144\frac{BTU}{lb}$$

$$\underline{\boldsymbol{Q = 288{,}000\ BTU}}$$

Example 6

- If 2,000 lb of ice must be formed in 24 hours, what is *rate of heat transfer*?

$$\dot{Q} = \frac{Q}{t}$$

$$\dot{Q} = \frac{288{,}000BTU}{24hr}$$

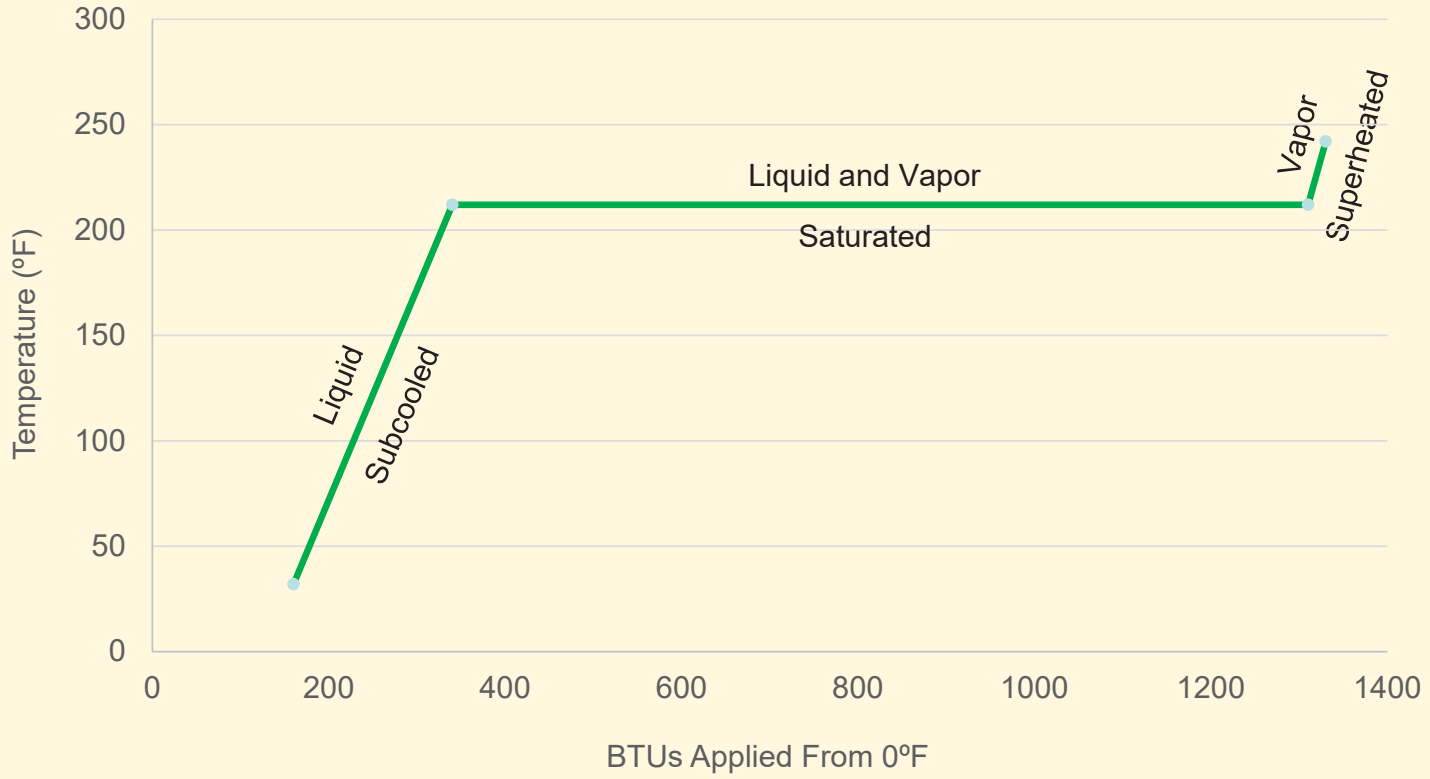
$$\dot{Q} = 12{,}000\frac{BTU}{hr}$$

$$\boldsymbol{\dot{Q} = 1\,Tr}$$

Refrigeration Tonnage

- 1 Ton of Refrigeration (Tr) is defined as the amount of heat required to freeze 2,000 lb of 32ºF water into ice.
- 1 Tr = 12,000 BTU/hr

Closing


300
250
200
150
100
50
0
Temperature (ºF)
0
200
400
600
800
1000
1200
1400
BTUs Applied From 0ºF
Liquid
Subcooled
Liquid and Vapor
Saturated
Vapor
Superheated

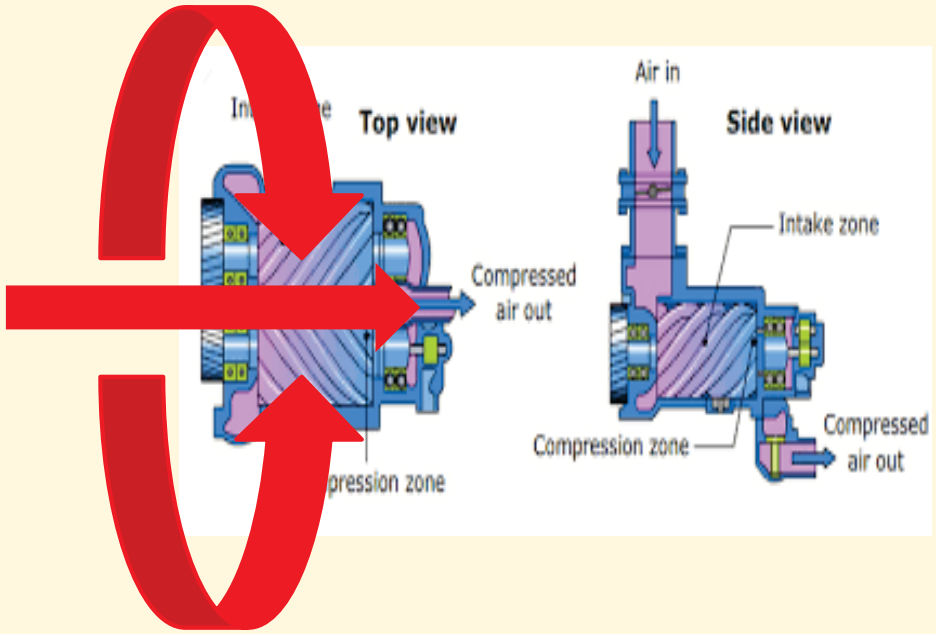
BREAK

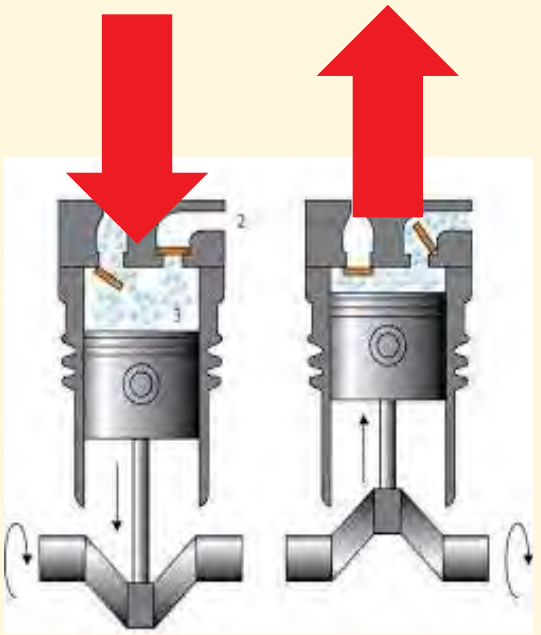
Refrigeration Components

Jennifer Montee – Resource Compliance, Inc.

Types of Compressors

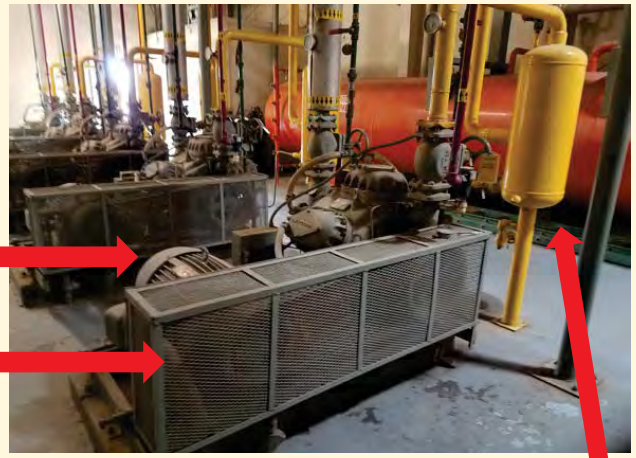
Screw Compressor vs. Reciprocating Compressor





Screw Compressor Components

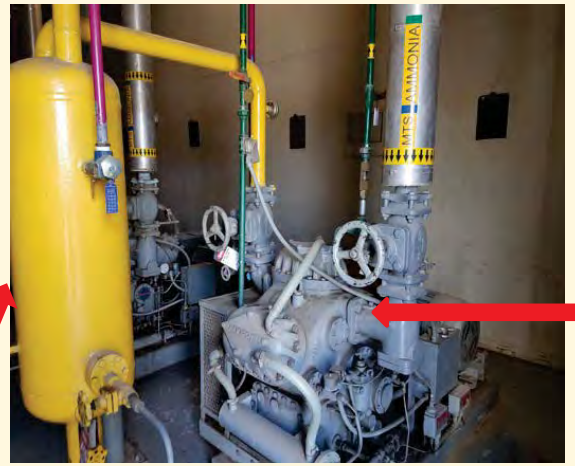
Reciprocating Compressor Components



MOTOR

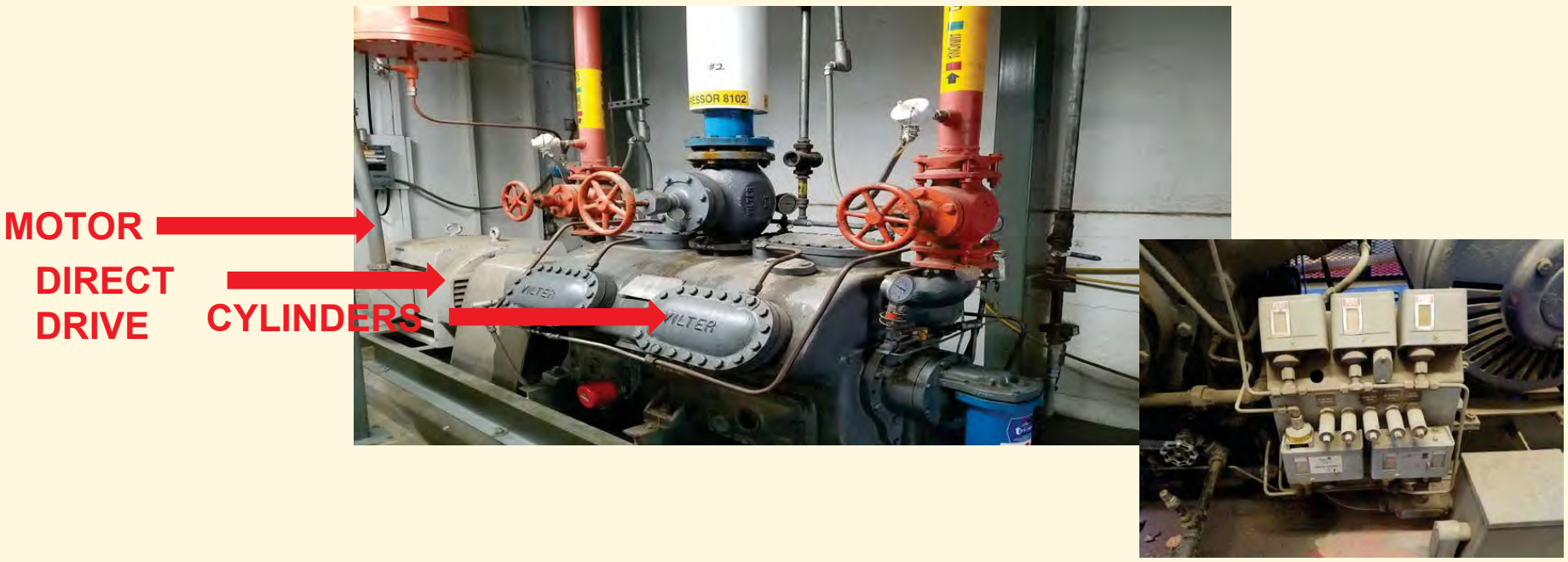
BELT

OIL SEPARATOR



COMPRESSOR

Reciprocating Compressor Components



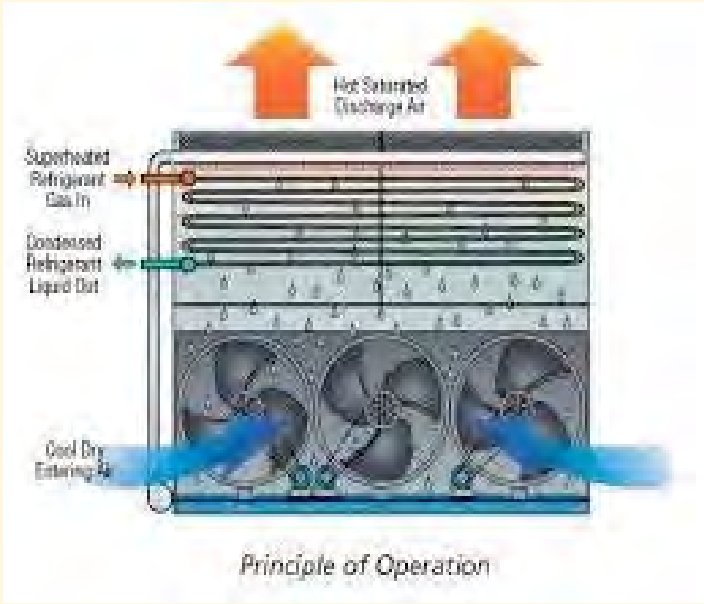
Types of Condensers

Evaporative

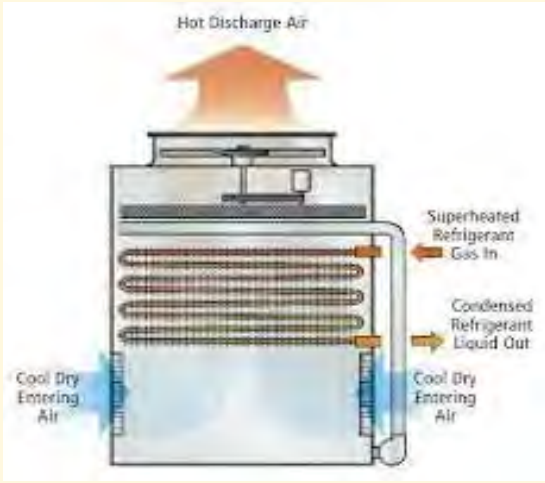
Plate and Frame

Air Cooled

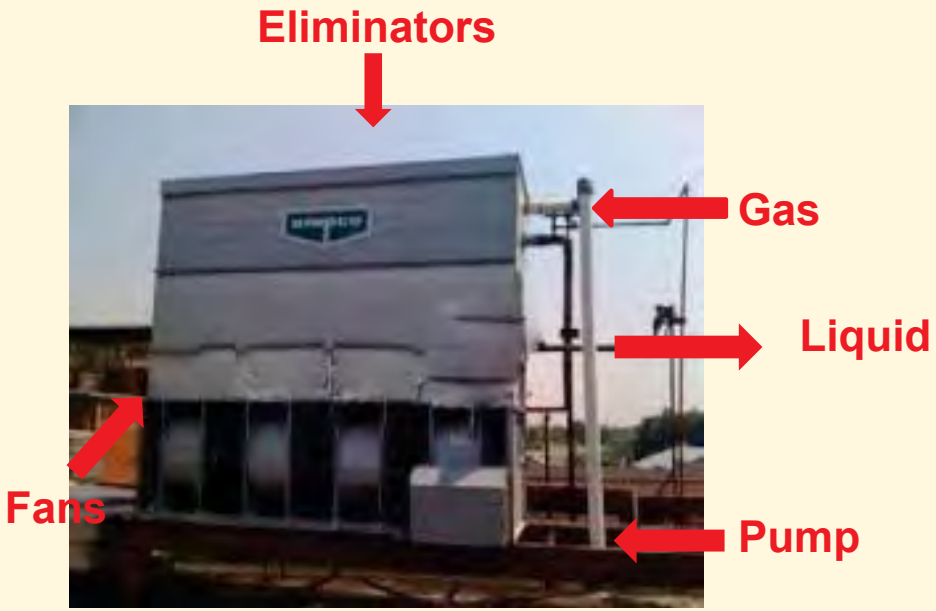
Evaporative Condenser - Forced Draft

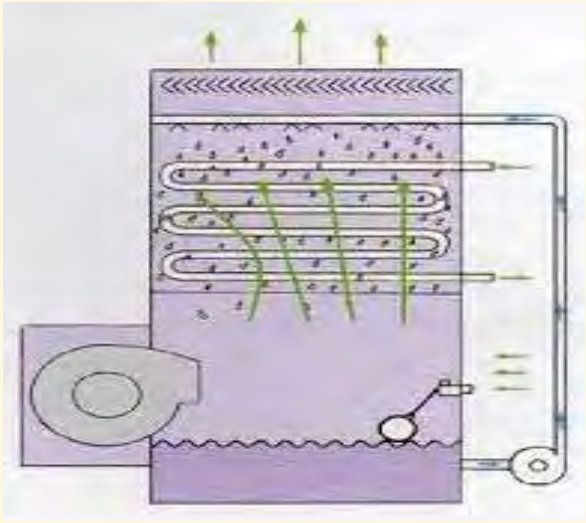


Evaporative Condenser - Induced Draft



Evaporative Condenser - Induced Draft, Centrifugal





Heat Exchangers

Air cooling

Product Cooling

Secondary Refrigerant Cooling

Air Cooling Heat Exchangers

Ceiling Suspended Evaporators

Air Handling Unit

Bunker Coil

Product Cooling Heat Exchangers

Storage Tank/Silo

Shell and Tube

Tube and Tube

Secondary Refrigerant Cooling

Plate and Frame

Shell and Tube

Secondary Refrigerants

- **Glycol**
- **Water**
- **Brine**

Different Types of Liquid Feeds for Heat Exchangers

Flooded

Direct Expansion

Recirculated

Heat Exchangers Used for Oil Cooling

Shell and Tube

Shell and Plate

Important Vessel Components

King Valve

Nameplate

High Level Float

Ammonia Pumps

Valves

Isolation

Control

Pressure Relief

Pipe


ASME SA53/SA106 GR.B/API 5L B PSL1/NACE MR0175/
0.200") x 21"H.5871H/2500
NDE/B.BLG-892/3.53 LBS/FT/IND

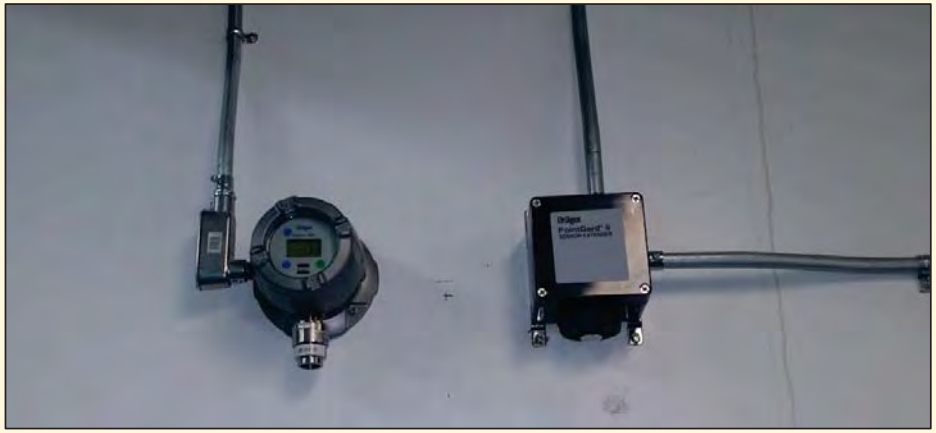
Stanislaus County Ammonia Refrigeration Training

Refrigeration Safety Systems

RESOURCE COMPLIANCE

Providing Solutions. Simplifying Regulation.

Ammonia Detection System



Ammonia Detection System

Sensor Location	Manuf.	Model	Serial Number	Type	Alarm Level	Audible Alarm	Strobe
Machinery Room	Dräger	PointGard II		Standalone	25 ppm-low 150 ppm-high	25 ppm	Amber-low Red-high
Machinery Room	Dräger	Polytron 5200		Standalone	14,000 ppm (1.4%)	N/A	N/A
Refrigerated Areas	Dräger	Polytron 5100		Sample	25 ppm	25 ppm	No

Compressor Safety Devices

- High Pressure Cutout
- Low Pressure Cutout
- Low Oil Cutout
- High Pressure Alarm
- Low Pressure Alarm
- Oil Pressure Alarm
- High Oil Temperature Cutout
- High Oil Temperature Alarm
- Low Oil Temperature Cutout
- Low Oil Temperature Alarm
- Discharge Temperature Cutout
- Discharge Temperature Alarm

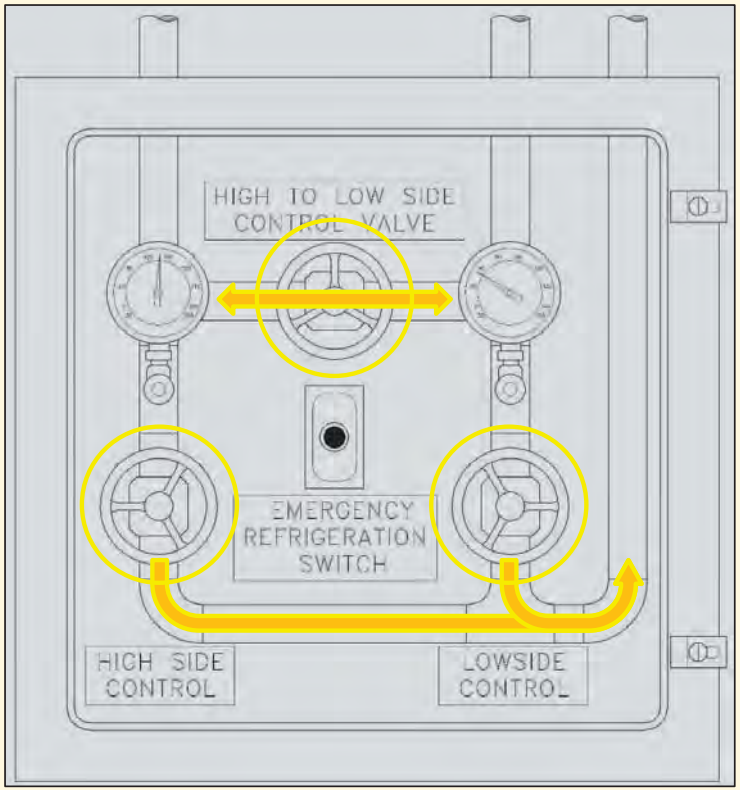
High Level Float Switch

A high level float switch is wired to shut down the compressors in the event of a high level situation. This prevents liquid ammonia from entering the compressor.

Level Controller

A level controller controls the liquid ammonia level in the vessel. The level controller is equipped with high level, control level, and low level set points.

Emergency Control Box



1. Often called a “Dump Box”
2. Installed for rare emergency situations

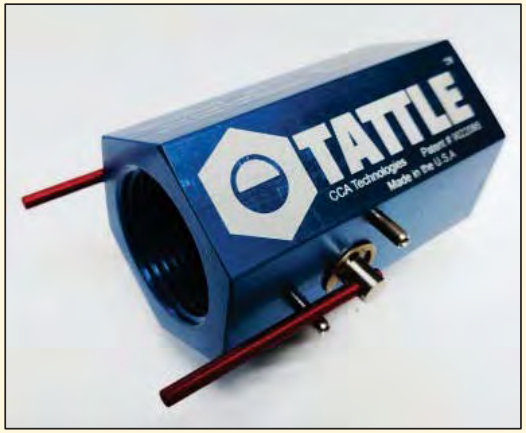
The Emergency Control Boxes were required by Fire Code prior to 2007. The control box *usually* contains three (3) valves.

- Valve #1: High Side Discharge Valve
- Valve #2: Low Side Discharge Valve
- Valve #3: High to Low Pressure Control Valve

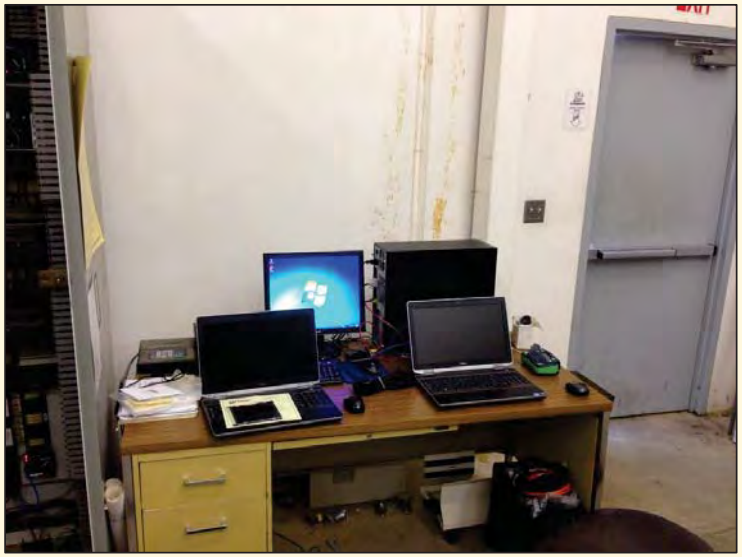
Emergency Pressure Control System

- Installations since 2007 should have and EPCS.
- Seldom used in a refrigeration system, but has been installed for rare emergency situations.
- An EPCS is activated automatically, whereas an ECB can only be activated manually.
- An ECB includes a provision for manually discharging the refrigeration system. An EPCS has no such provision.

Relief Vent Indicators



Computer Control System



Switch and Light Panel

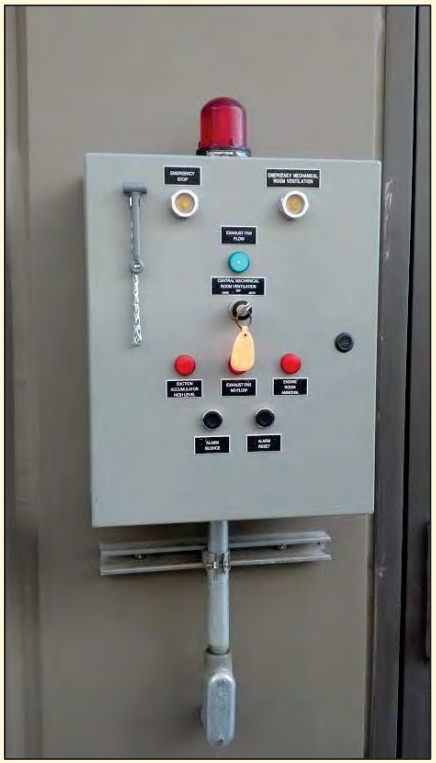
Diffusion Tanks

- California started requiring Diffusion Tanks in 1994 with the Uniform Mechanical Code (UMC). The first California Mechanical Code (CMC) also required them in 1998.
- 2016 CMC (effective Jan. 1, 2017) removed all references to diffusion tanks.
- “Era of Diffusion Tanks” 1994-2016.

Main Liquid Feed Shut-Off Valve (King Valve)

- The high pressure receiver is equipped with a main liquid feed shut-off valve (king valve)
- It should be clearly labeled and can be used to stop the flow of ammonia throughout the system.

Emergency Refrigeration Switch



Emergency Eyewash and Shower Station

Overview of RAGAGEP

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

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.

IIAR Literature - Bulletins

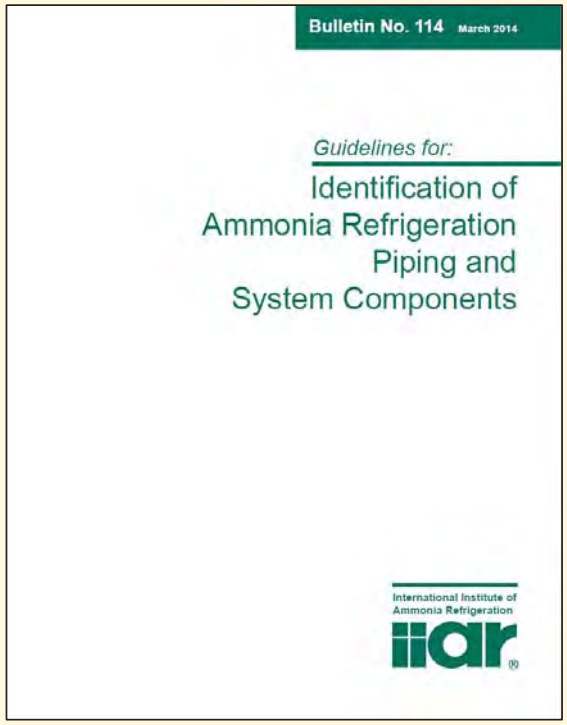
IIAR Bulletin No. 110 §6.4.2 [emphasis mine]:

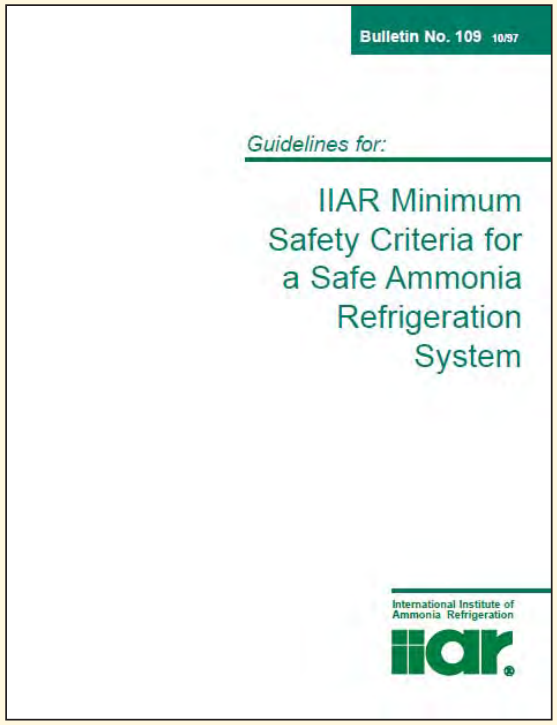
The system should be checked regularly for the presence of non-condensable gases which should be purged as necessary from the receiver(s) and/or condenser(s), preferably into a noncondensable gas remover or purger but alternatively into water. Where an automatic purger is fitted, its correct operation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

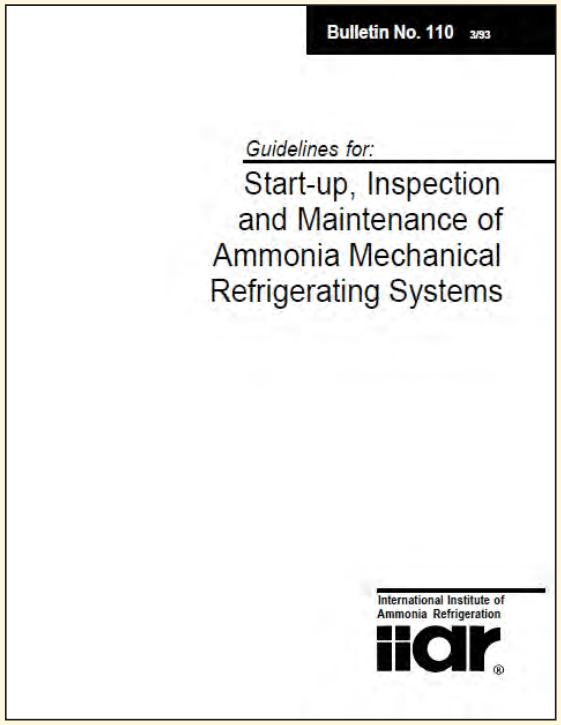
IIAR Suite of Standards

- **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







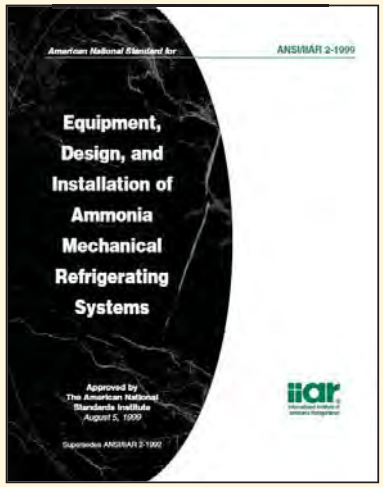
IIAR Standard 2

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

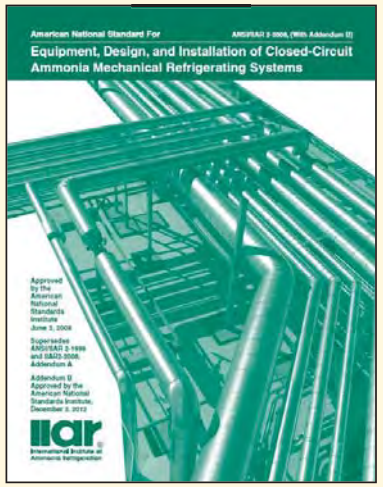
1974-78

1984

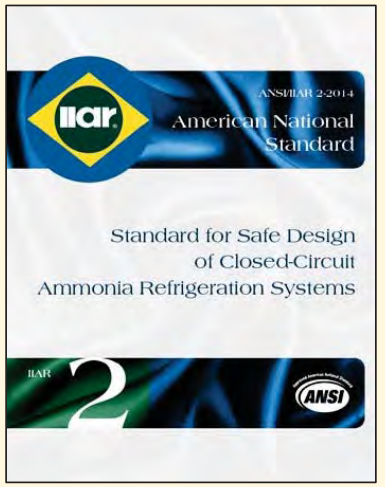
1999



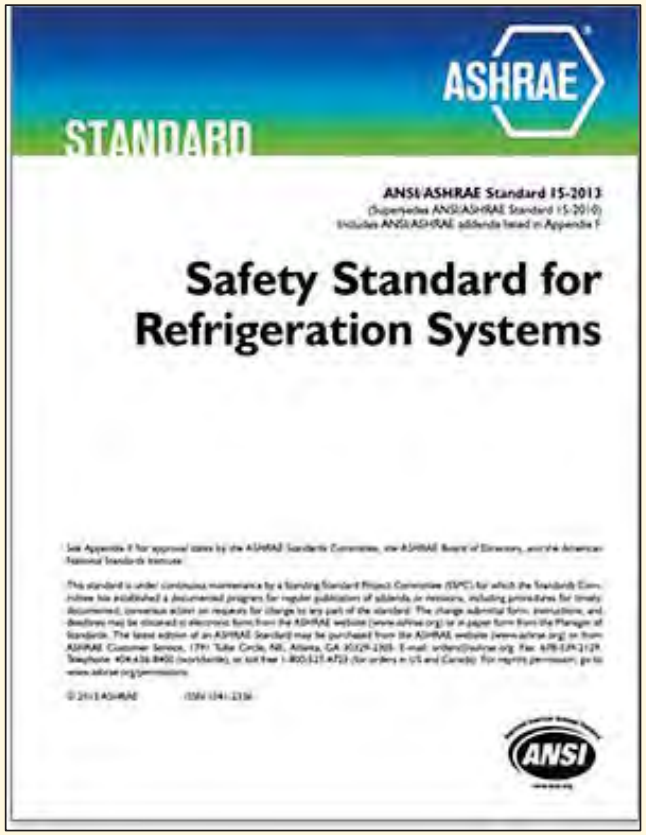
2008



2014

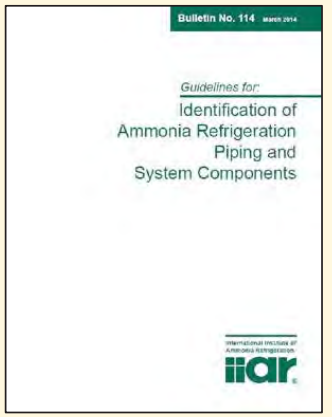


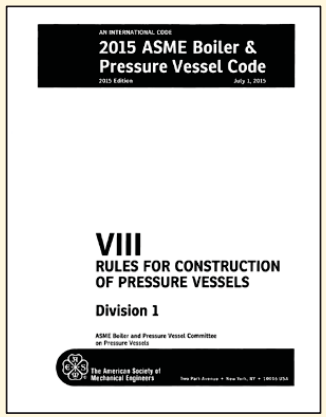
IIAR 2 vs. ASHRAE 15

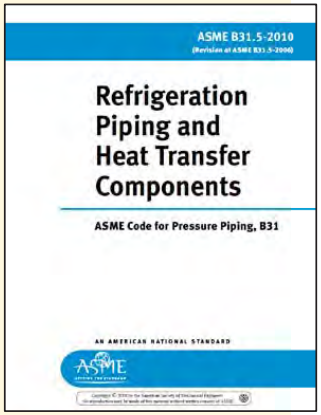


Other RAGAGEP Documents

- 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

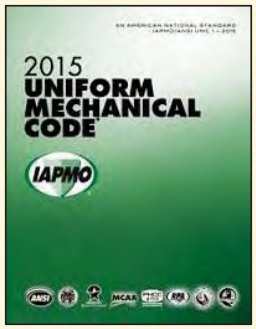
- **2015 IFC §606.12.1.1 Ammonia refrigeration.** Refrigeration systems using ammonia refrigerant and the buildings in which such systems are installed shall comply with **IIAR-2** for system design and installation and **IIAR-7** for operating procedures.
- **2015 NFPA 1 §53.1.3 Reference Codes and 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.

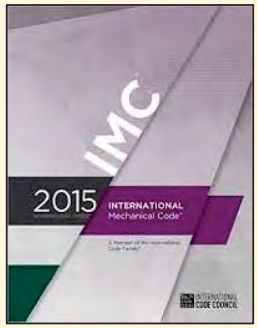
iar® International Institute of Ammonia Refrigeration

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**.

iar®
International Institute of Ammonia Refrigeration





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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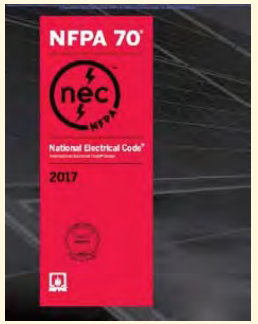
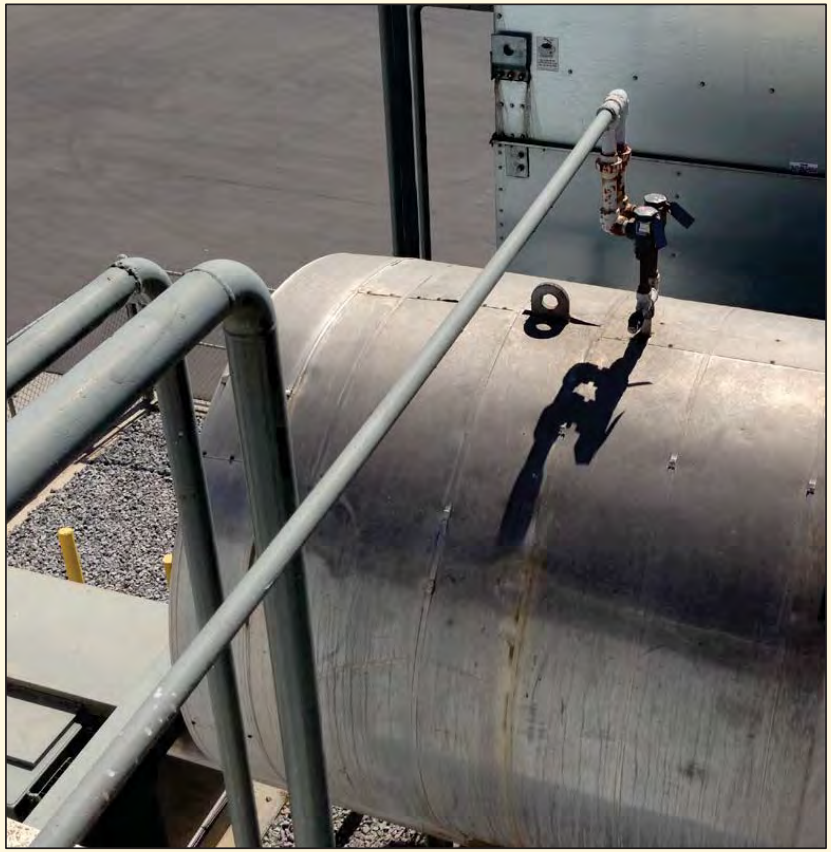


Conflicts in RAGAGEP

- **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

Grandfathering

Scenario:

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

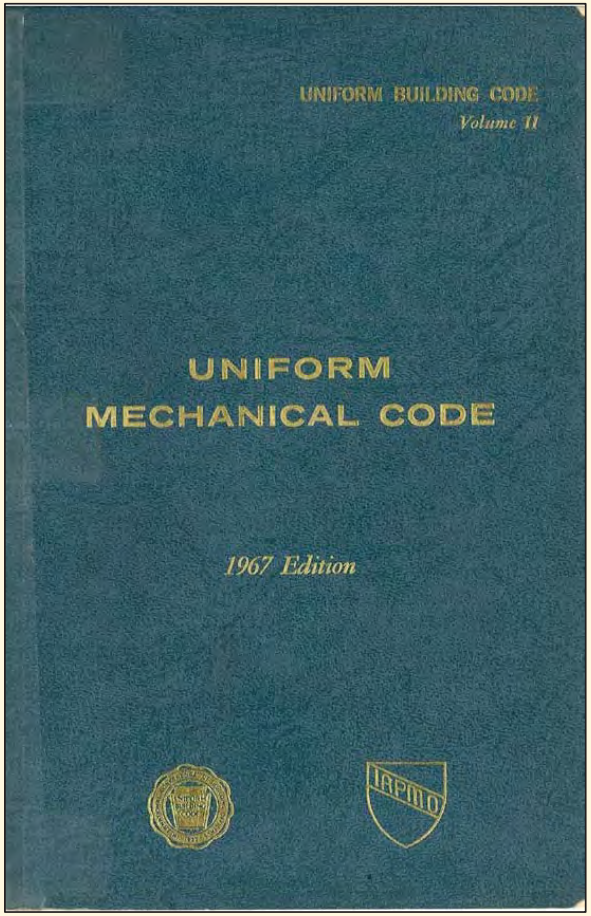
U.M.C. STANDARD 15-1-67 UNIFORM MECHANICAL CODE

UNIFORM MECHANICAL CODE STANDARD NO. 15-1-67

MECHANICAL REFRIGERATION

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

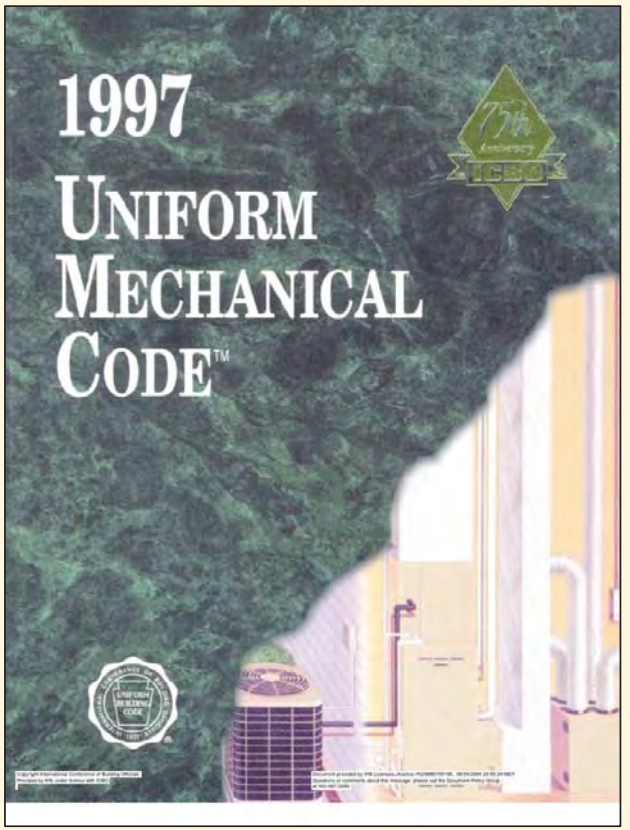
See Section 1501, Uniform Mechanical Code



Grandfathering

Scenario:

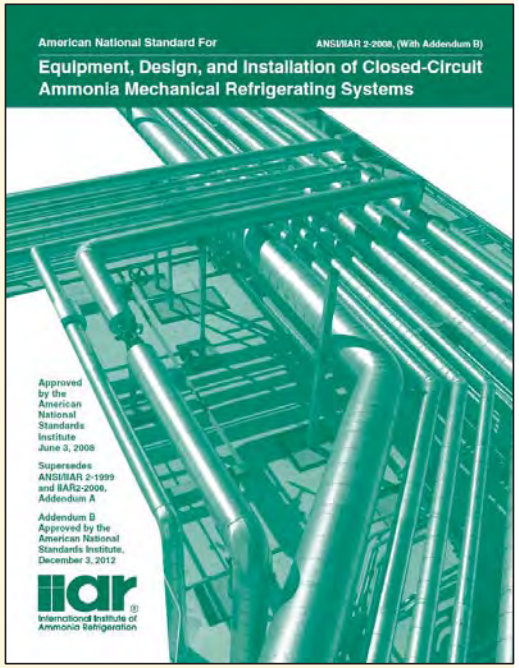
- In 1998, modifications were made to the machinery room
  - New compressor installed
  - AHJ required ventilation and detection to be upgraded
  - All changes performed in accordance with 1997 UMC



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



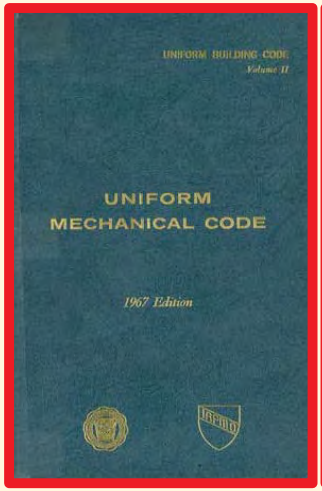
Grandfathering

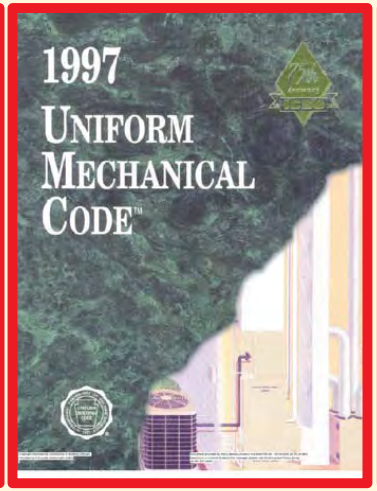
What RAGAGEP is applicable at the facility?

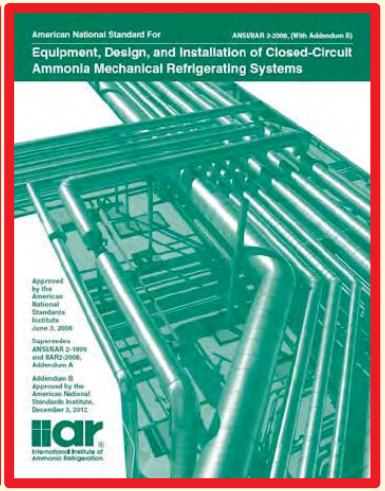
Originally Installed System

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.

Ammonia Detection and Ventilation

Jennifer Montee – Resource Compliance, Inc.

Does your facility…..

Have ammonia detection?

Have machinery room ventilation?

Are they tied together?

Ammonia Detection

- **Level 1 –** Where ammonia equipment is installed.
- **Level 2 –** Where packaged systems are located indoors and outside of a machinery room.
- **Level 3 –** With indoor pits or locations that require emergency ventilation
- **Machinery Rooms –** Enclosed space containing refrigeration equipment.

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

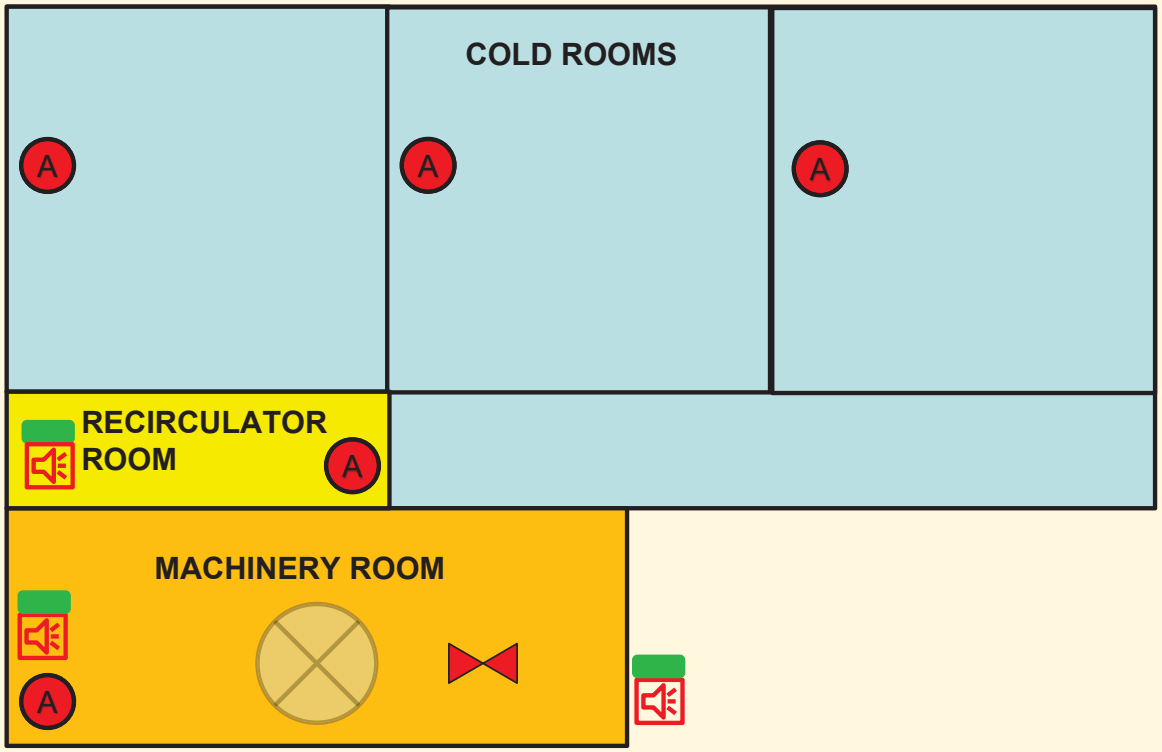
- Detection of ammonia concentrations less than **25 ppm** requires no alarm.
- Detection of **150 ppm** must activate emergency ventilation with manual reset required.
- Detection of **40,000 ppm** or vapor detector's upper limit must cause the following equipment to automatically de-energize:
  - Refrigerant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

[ANSI/IIAR 2-2014 §6.13.2]

RESOURCE COMPLIANCE

Providing Solutions. Simplifying Regulation.

Ammonia Detection Example



MACHINERY

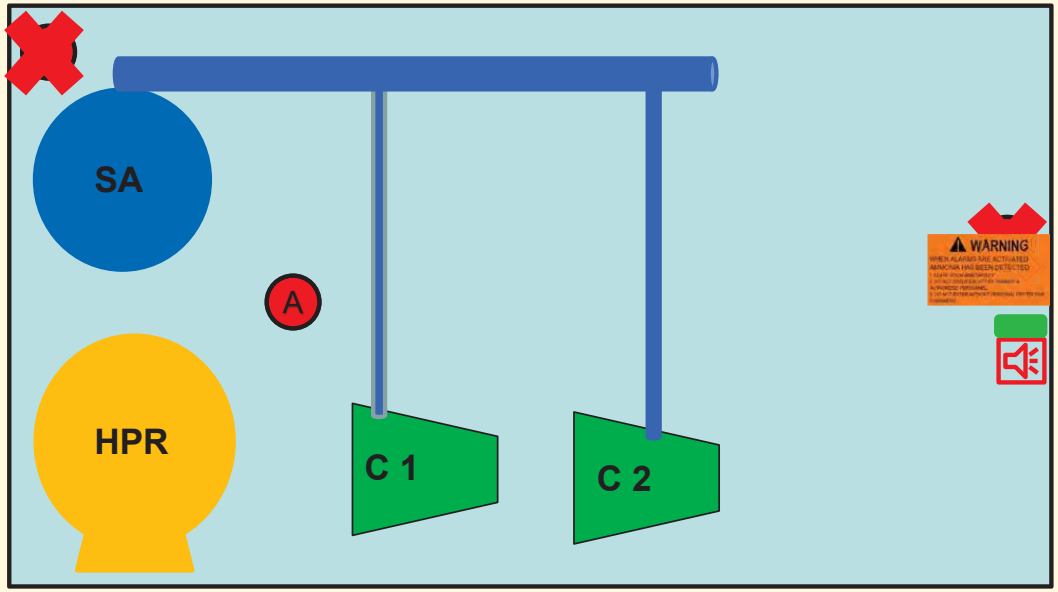
25 PPM
150 PPM
40,000 PPM

GUARD STATION

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]

Does your facility……

- ✓ **Have ammonia detection?**

Have machinery room ventilation?

Are they tied together?

Machinery Room Ventilation

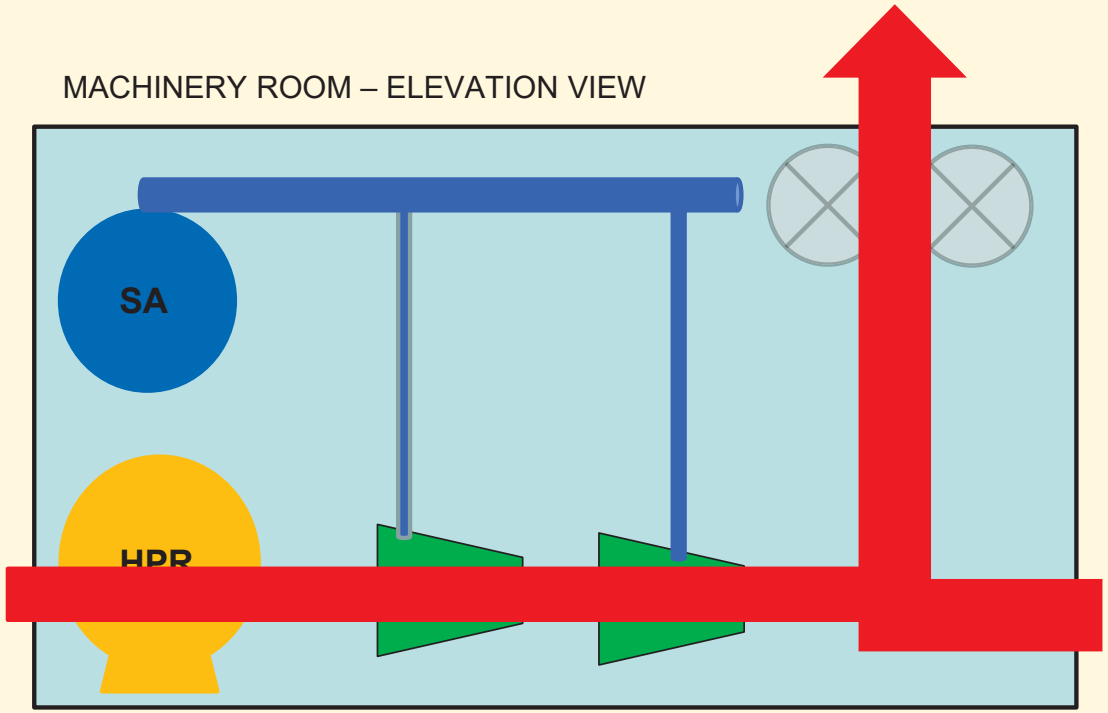
1. Emergency Ventilation
2. Temperature Control

Are all machinery rooms required to have ventilation?

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

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.

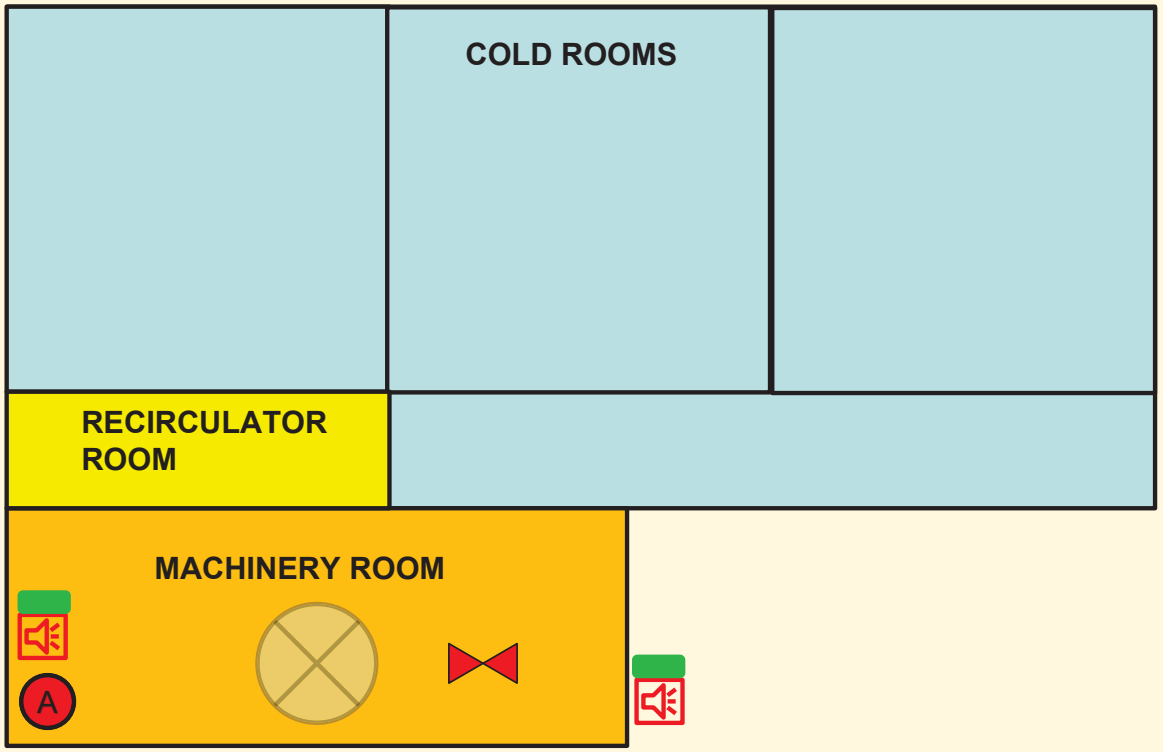
[ANSI/IIAR 2-2014 §17.3]

Does your facility….

- ✓ **Have ammonia detection?**
- ✓ **Have machinery room ventilation?**

Are they tied together?

Emergency Ventilation and Ammonia Detection



25 PPM
150 PPM
40,000 PPM

Does your facility….

- ✓ Have ammonia detection?
- ✓ Have machinery room ventilation?
- ✓ Are they tied together?

RAGAGEP: System Identification

Uriah Donaldson, OHST – Process Safety Consultant

Polling Question

Which pipe is the ammonia liquid?

Overview of this Talk

1. Pipe Labeling
2. Component Labeling
3. Valve Tagging
4. System Signage

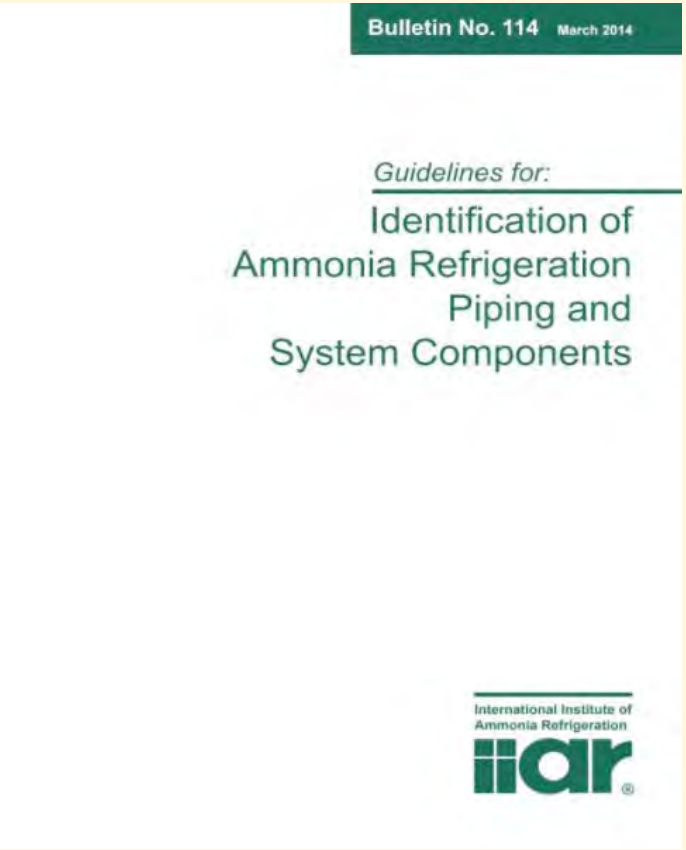
Pipe Labeling

RESOURCE COMPLIANCE

Pipe Labeling

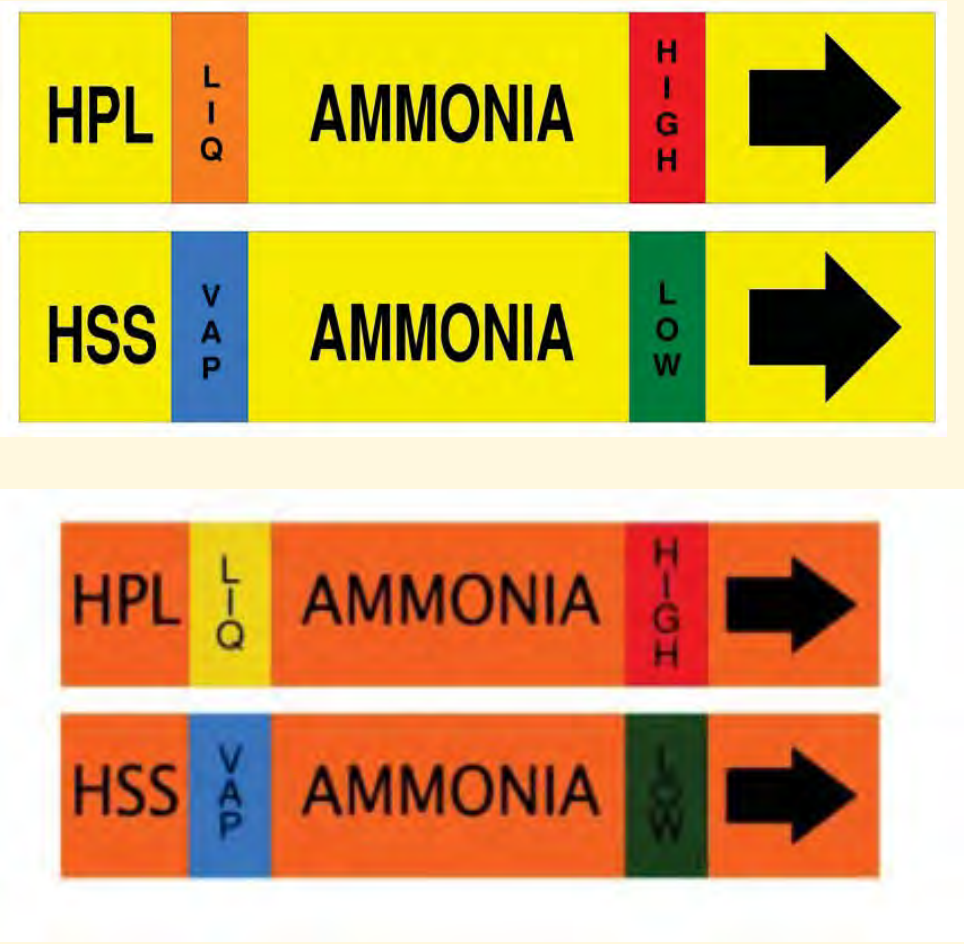
1. “AMMONIA”
2. Physical state of ammonia
3. Relative pressure (high or low)
4. Pipe service (HPL, CD, HSS)
5. Direction of flow

RESOURCE COMPLIANCE



Pipe Labeling

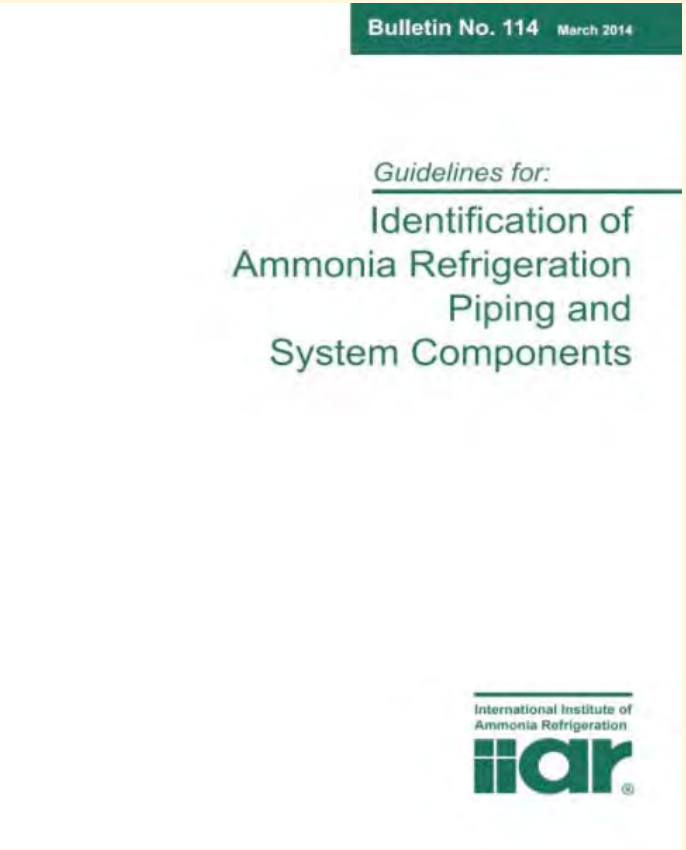
1. Marker body in SAFETY ORANGE with the word AMMONIA printed in black
2. Physical state of ammonia
3. Relative pressure (high or low)
4. Pipe service (HPL, CD, HSS)
5. Direction of flow


HPL
LIQ
AMMONIA
HIGH
HSS
VAP
AMMONIA
LOW
HPL
LIQ
AMMONIA
HIGH
HSS
VAP
AMMONIA
LOW


PO
AMMONIA
HGD
AMMONIA
HTRL (-35°F)
AMMONIA
LTRS (-35°F)
AMMONIA
OPO (-35°F)
AMMONIA


TSR
AMMONIA
TSS
AMMONIA

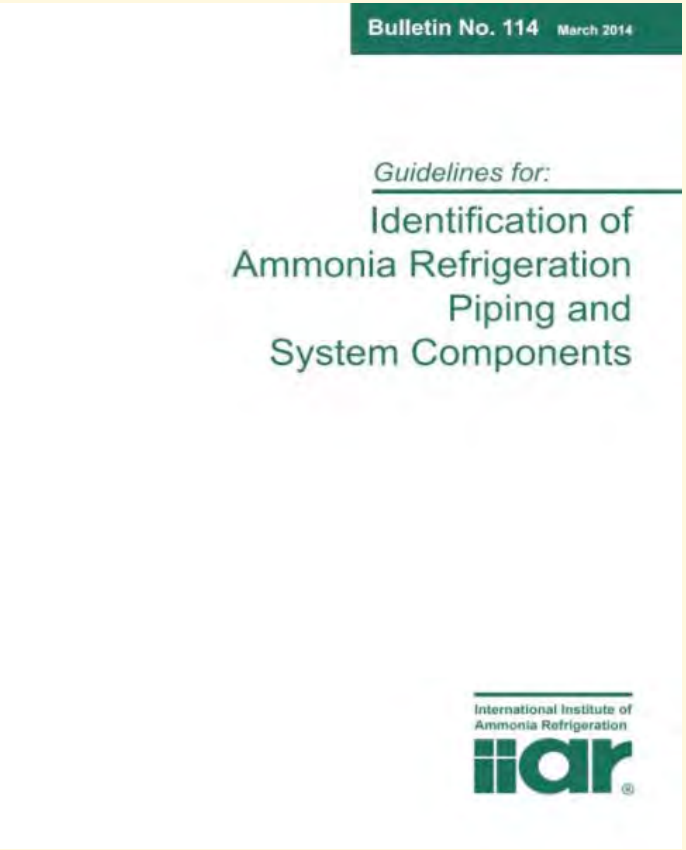
RESOURCE COMPLIANCE



Pipe Labeling - Location

1. Before and after a change in direction
2. Before and after pipe penetrations
3. Maximum spacing of 40’ on horizontal or vertical pipe runs
4. At least one on the piping in every area through which the refrigeration piping passes

RESOURCE COMPLIANCE



Pipe Coloring – Q&A

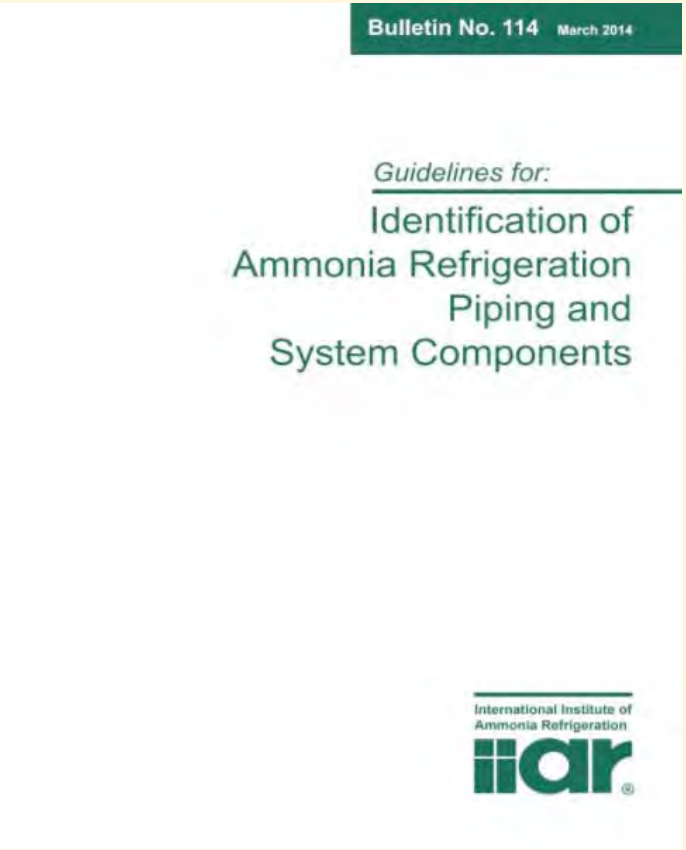
Q: Do I have to have a pipe color code?

A: No. Pipes can be painted the same color.


PO
AMMONIA
HGD
AMMONIA
HTRL (-35°F)
AMMONIA
LTRS (-35°F)
AMMONIA
OPO (-35°F)
AMMONIA


TSR
AMMONIA
TSS
AMMONIA

RESOURCE COMPLIANCE

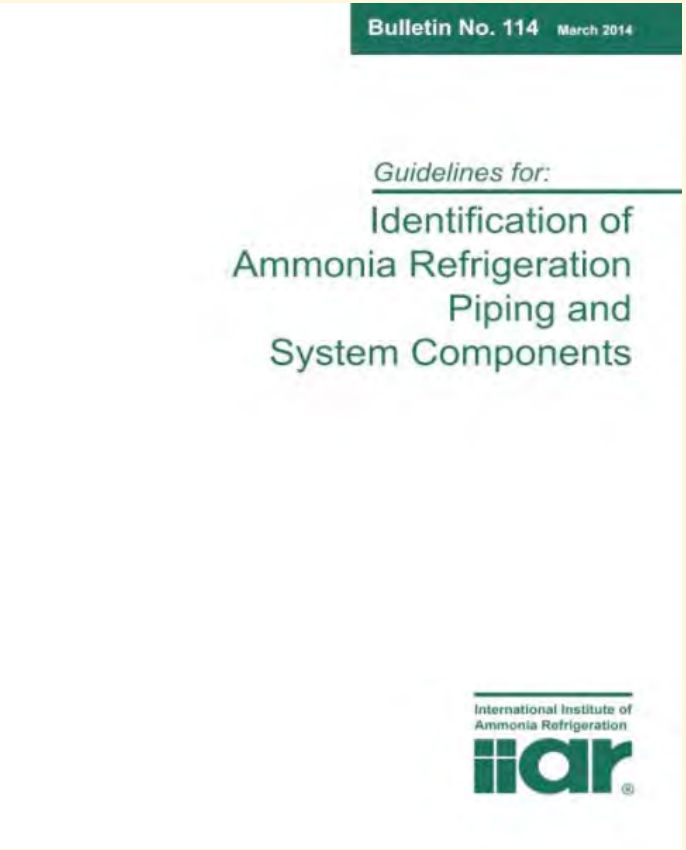


Pipe Coloring – Q&A

Q: Do I have to follow IIAR Bulletin 114's Color Scheme?

A: No. Facilities may select an alternate color scheme…. The scheme should be consistent through the facility and a legend posted.

RESOURCE COMPLIANCE

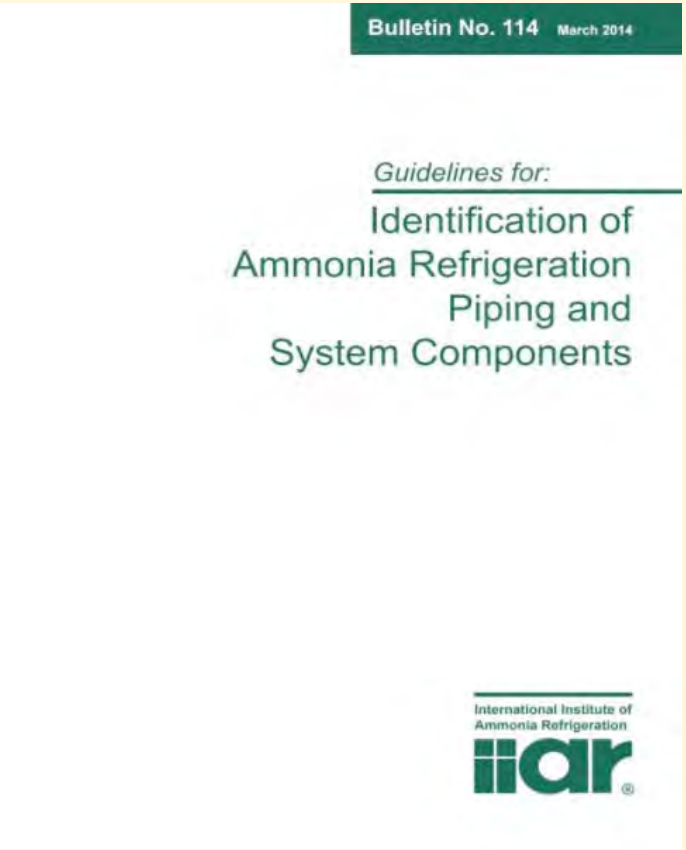


Pipe Coloring

High Pressure Liquid = Orange
High Pressure Vapor = Yellow
Low Pres / High Temp = Light Blue
Low Pres / Low Temp = Dark Blue
Relief Vent = Grey
Water = Green

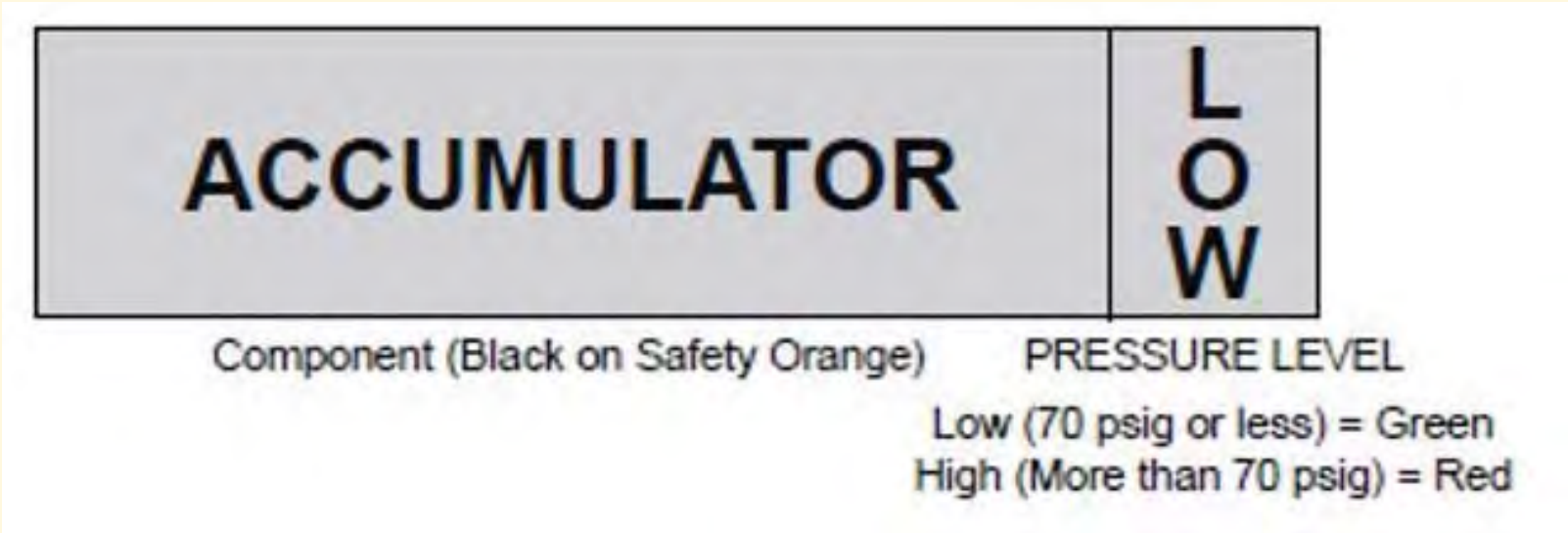
Component (Equipment) Labeling

RESOURCE COMPLIANCE



Component Labels

1. Name of the Equipment
2. Pressure Designation
3. Black letters on a SAFETY ORANGE background


ACCUMULATOR
LOW
Component (Black on Safety Orange)
PRESSURE LEVEL
Low (70 psig or less) = Green
High (More than 70 psig) = Red

RESOURCE COMPLIANCE

Nameplates

"Equipment shall have a nameplate with minimum data that describes the manufacturer's information and design limits…." [ANSI/IIAR 2 -2014 §5.14.4]

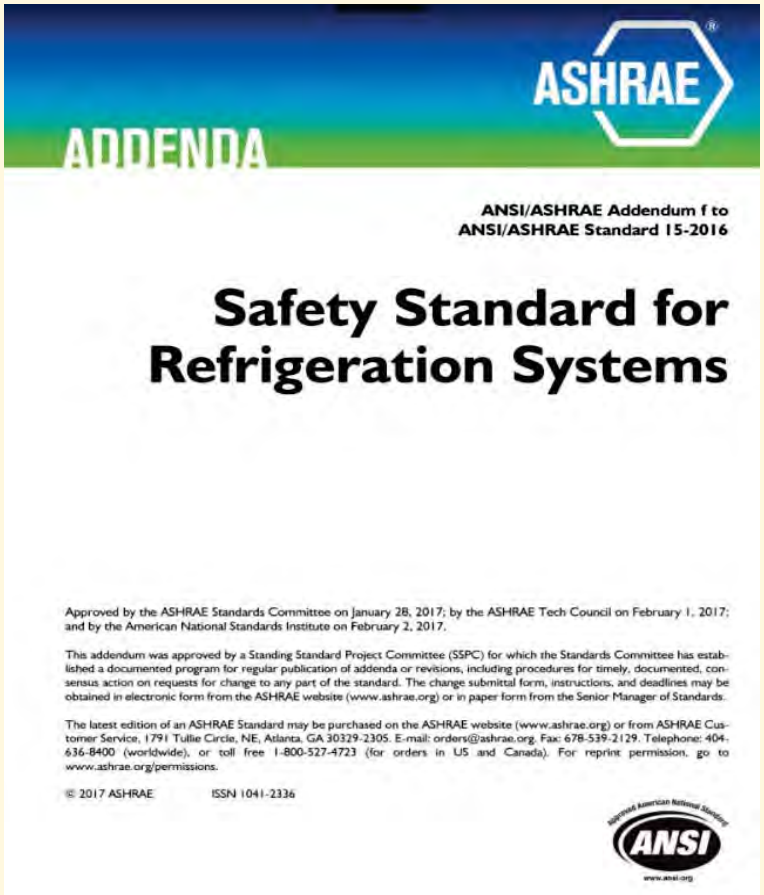
Valve Tagging

RESOURCE COMPLIANCE

Valve Tagging

"Valves required for emergency shutdown of the system shall be clearly and uniquely identified at the valve itself and in the system schematic drawings" [ANSI/IIAR 2-2014 §5.14.3]

RESOURCE COMPLIANCE


ASHRAE

ADDENDA

ANSI/ASHRAE Addendum f to
ANSI/ASHRAE Standard 15-2016

Safety Standard for Refrigeration Systems

Approved by the ASHRAE Standards Committee on January 28, 2017; by the ASHRAE Tech Council on February 1, 2017; and by the American National Standards Institute on February 2, 2017.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards.

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ANSI

Valve Tagging

"Stop valves shall be suitably labeled if the components to and from which the valve regulates flow are not in view at the valve location" [ANSI/ASHRAE 15-2016 §9.12.6]

RESOURCE COMPLIANCE

Valve Tag – Q&A

Q: What should a Valve Tag look like?

A: In general, a valve tag should correspond to the system's P&IDs.

A valve tag should be helpful.

System Signage

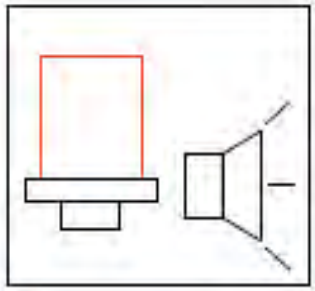
RESOURCE COMPLIANCE

Alarms

"Ammonia leak detection alarms shall be identified by signage adjacent to visual and audible alarm devices" [§17.6]

"The meaning of each alarm shall be clearly marked by signage near the visual and audible alarm" [§13.2.4.1]

RESOURCE COMPLIANCE



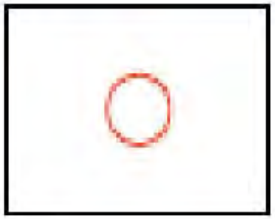
WARNING

WHEN ALARMS ARE ACTIVATED AMMONIA HAS BEEN DETECTED:

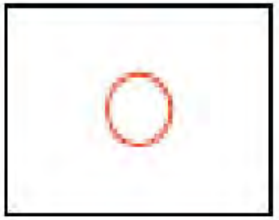
1. LEAVE ROOM IMMEDIATELY
2. DO NOT ENTER EXCEPT BY TRAINED & AUTHORIZED PERSONNEL
3. DO NOT ENTER WITHOUT PERSONAL PROTECTIVE EQUIPMENT

REFRIGERATION MACHINERY **SHUTDOWN** EMERGENCY USE ONLY

BREAK GLASS TO PUSH BUTTON



REFRIGERATION MACHINERY ROOM **VENTILATION** EMERGENCY USE ONLY



RESOURCE COMPLIANCE

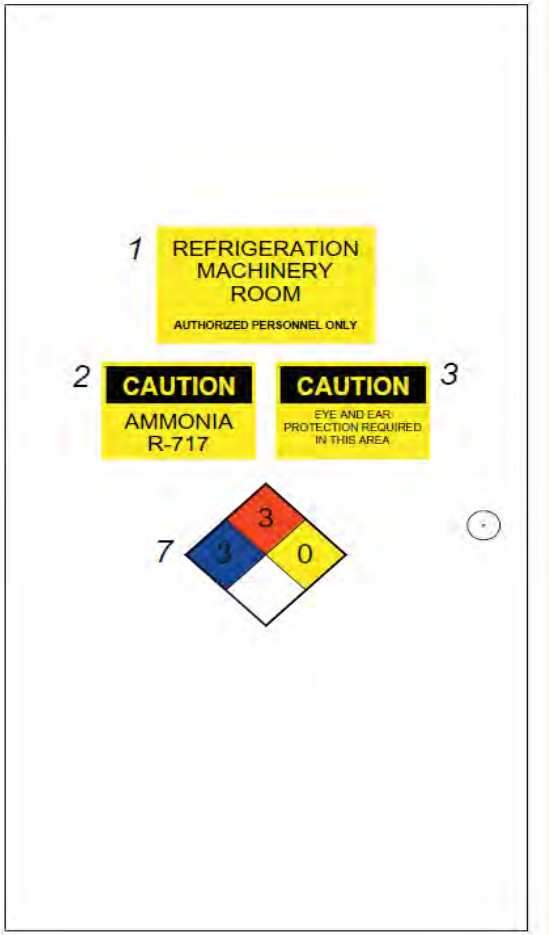
RESOURCE COMPLIANCE

Machinery Rooms

"Buildings and facilities with refrigeration systems shall be provided with placards accordance with NFPA 704" [§6.15.1]

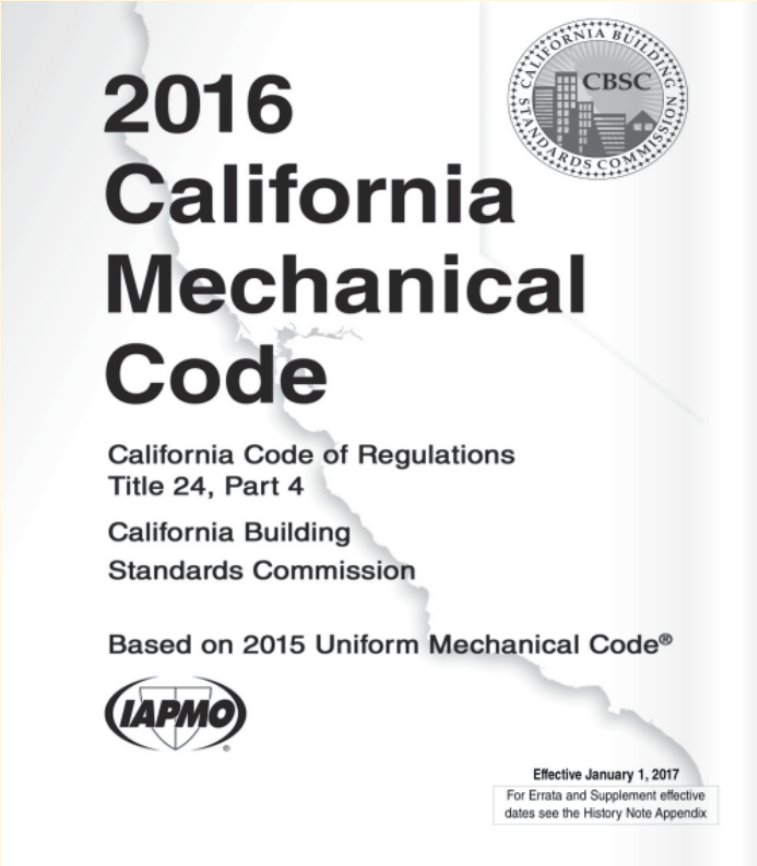
"Each machinery room entrance door shall be marked… to indicated that only authorized personnel are permitted" [§13.2.4.1]

RESOURCE COMPLIANCE



RESOURCE COMPLIANCE

RESOURCE COMPLIANCE



Machinery Rooms

"…There shall be a permanent sign at an approved location giving the following information:

1. Name of contractor installing the equipment.
2. Name and number designation of refrigerant in system.
3. Pounds of refrigerant in system" [2016 CMC §1115.3]


INDUSTRIAL REFRIGERATION
MECHANICAL SYSTEM INSTALLED BY:
CAL CA
CALIFORNIA CONTROLLED ATMOSPHERE
CLN 481142
39138 RD. 56
DINUBA, CA 93618
(559) 591-8874
FAX (559) 591-8896
SYSTEM INSTALLED FOR:
SYSTEM INFORMATION:
REFRIGERANT
CHARGE
TESTING:
HIGH SIDE
LOW SIDE
EMERGENCY INFORMATION

Mechanical Integrity (MI)

By: Nate Torres – Operations Manager

Outline

- What is Mechanical Integrity?
- Purpose of Mechanical Integrity?
- Scope of Mechanical Integrity Program
- Keys to effective Mechanical Integrity Program

What is Mechanical Integrity?

An *organized* plan for performing the following activities on a refrigeration system:

1. **Inspections**

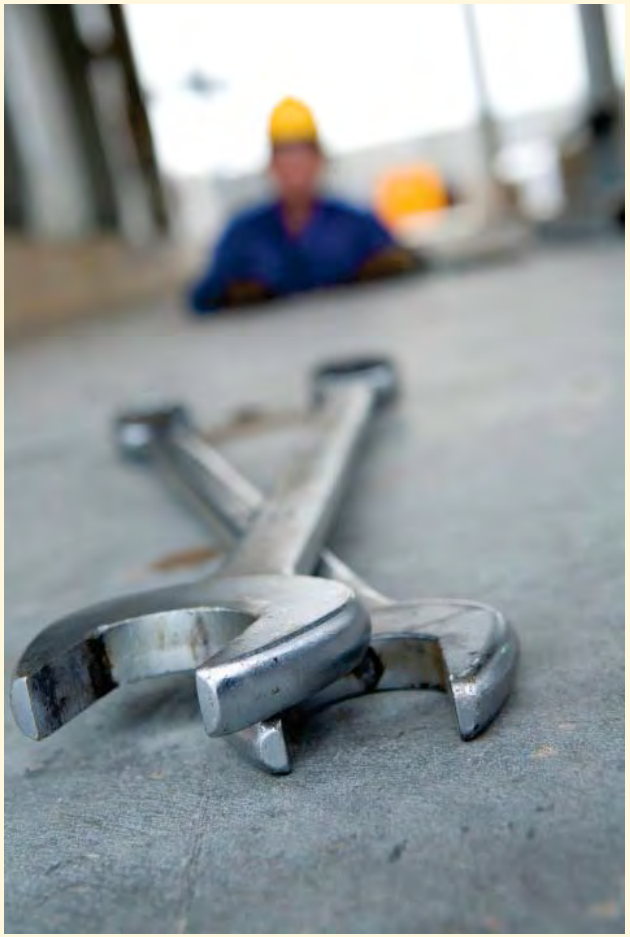
(Visual)

2. **Testing**

(Vibration Analysis/Safety Devices/Oil Sampling)

3. **Maintenance**

(Draining Oil/Exercising Valves)



Purpose

1. Prevent failure of system
2. Minimize system down time
3. Prevent accidental releases of ammonia
4. Maximize efficiency of system operation
5. Maximize life of system

Application

- Pressure Vessels
- Heat Exchangers
- Piping and Valves
- Compressors
- Relief System
- Emergency Shut Down System
- Pumps

** Any component of the process or associated with the process that can cause process failures or accidental releases.*

Basis

RAGAGEP

1. **Industry Standards**

   IIAR Bulletins and Standards

2. **Manufacturer's Recommendation**

   IOM Manuals

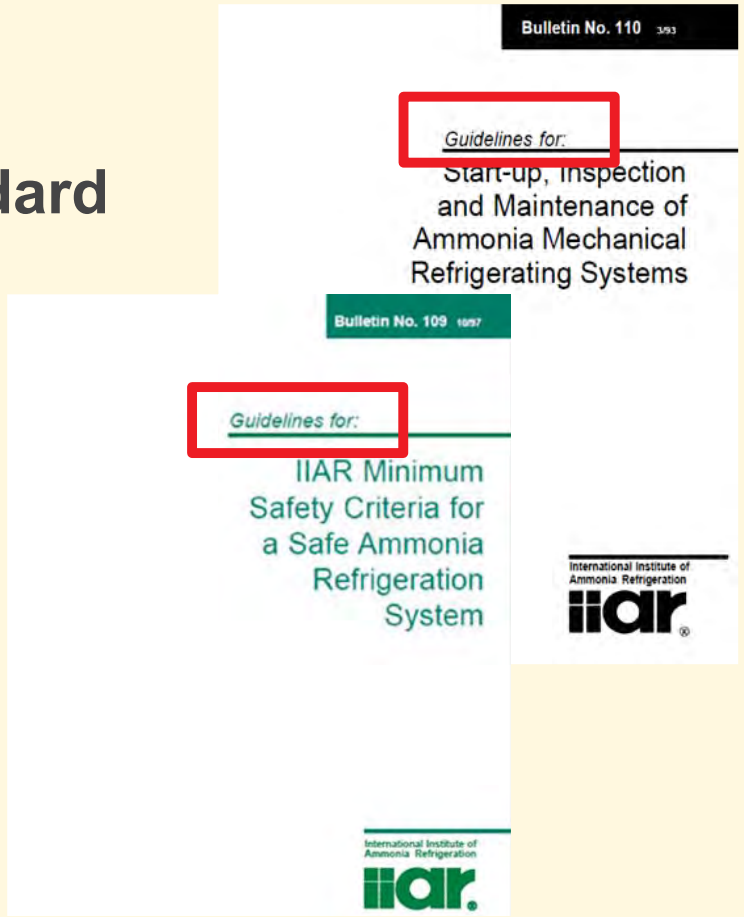
3. **Prior Operating Experience**

   Historical Operating Data

Industry Standards

<u>*Currently*</u> being used as Industry Standard

- IIAR Bulletin 109 & 110
  - *"Guidelines"*



Industry Standards

***Coming Soon*: Industry Standards**

- ***IIAR 6*** - *Inspection, Testing, and Maintenance of Safe Closed-Circuit Ammonia Refrigeration Systems*

*"**minimum** criteria for inspection, testing, and maintenance of closed-circuit ammonia mechanical refrigeration systems"*

IIAR 6-201x

Public Review Announcement

March 31, 2017

First (1st) Public Review of Standard BSR/IIAR 6-201x, *Standard for Inspection, Testing, and Maintenance of Safe Closed-Circuit Ammonia Refrigeration Systems*

The first (1st) public review of draft standard BSR/IIAR 6-201x *Standard for Inspection, Testing, and Maintenance of Safe Closed-Circuit Ammonia Refrigeration Systems* is now open. The public review will be conducted from March 31, 2017 through May 15, 2017. Comments must be submitted to the International Institute of Ammonia Refrigeration (IIAR) by 5:00 pm Eastern Standard Time on May 15, 2017.

The International Institute of Ammonia Refrigeration (IIAR) invites you to make comments on the draft standard. Substantive changes resulting from this public review will also be provided for comment in a future public review if necessary.

CLICK HERE TO ACCESS COMMENT FORMS

MI Program Elements

1. **Schedule** of all ammonia refrigeration equipment
2. **Frequency** of inspections, tests, and maintenance
3. **Procedure** to perform each task
4. **Form** to document task results and identify deficiencies
5. **System** to ensure deficiencies tracked to completion

Example: Evaporative Condenser

1. Visual Inspections

Weekly, Monthly, Annual, and 5-yr

2. Testing

Weekly Water Treatment Testing

3. Maintenance

Lubricate Fan Bearings Quarterly

Annual Cleaning of Water Sump and Strainers

Example: Evaporative Condenser

Evaporative Condenser	Frequency	Operating Procedure	Form
Visual Inspections	Weekly Inspection	SOP-101	EC-W
	Monthly Inspection	SOP-101	EC-M
	Annual Inspection	SOP-101	EC-A
	5-year Inspection	SOP-101	EC-5yr
Testing	Weekly Water Treatment Test	SOP-102	EC-WTT
Maintenance	Quarterly Fan Bearings Service	SOP-103	EC-QFB
	Annual Sump Cleaning	SOP-103	EC-ASC

Example: Evaporative Condenser

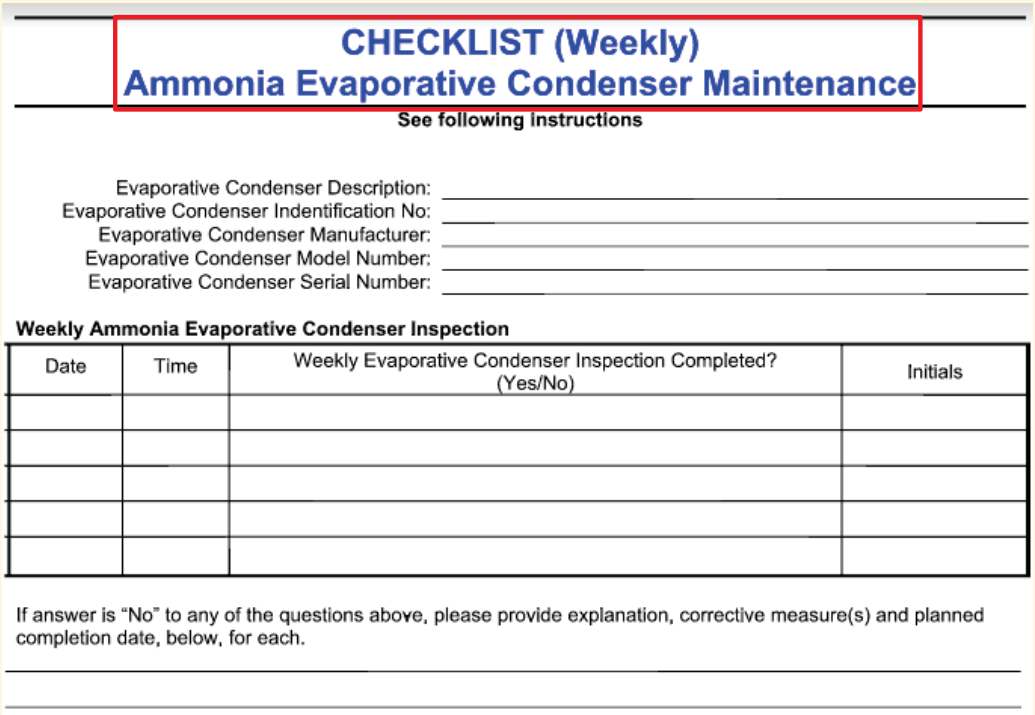
Visual Inspections of Evaporative Condensers

Weekly Evaporative Condenser Inspection:

- Entering the evaporative condenser basin through the access-door is a permit-required confined space activity. Follow all required confined space protocols;
- Make sure that the evaporative condenser shows no signs of an ammonia leak;
- Make sure that evaporative condenser and associated water piping is free from leaks;
- Make sure that the evaporative condenser is not experiencing unusual vibration;
- Make sure that non-authorized personnel are not working on or around the evaporative condenser;
- Make sure that the evaporative condenser has safe access in the event that the evaporative condenser must be worked on;
- Visually inspect the belt(s) for proper tension;
- Make sure that the basin strainer is clear of debris;
- Visually inspect the evaporative condenser for any unusual sights, sounds, or smells. Any unusual conditions must be addressed.

Example: Evaporative Condenser

Visual Inspections of Evaporative Condensers



CHECKLIST (Weekly)
Ammonia Evaporative Condenser Maintenance

See following instructions

Evaporative Condenser Description: _____
Evaporative Condenser Indentification No: _____
Evaporative Condenser Manufacturer: _____
Evaporative Condenser Model Number: _____
Evaporative Condenser Serial Number: _____

Weekly Ammonia Evaporative Condenser Inspection

Date	Time	Weekly Evaporative Condenser Inspection Completed? (Yes/No)	Initials

If answer is "No" to any of the questions above, please provide explanation, corrective measure(s) and planned completion date, below, for each.

_____

_____

Example: Evaporative Condenser

Evaporative Condenser	Frequency	Operating Procedure	Form
Visual Inspections	Weekly Inspection	SOP-101	EC-W
	Monthly Inspection	SOP-101	EC-M
	Annual Inspection	SOP-101	EC-A
	5-year Inspection	SOP-101	EC-5yr
Testing	Weekly Water Treatment Test	SOP-102	EC-WTT
Maintenance	Quarterly Fan Bearings Service	SOP-103	EC-QFB
	Annual Sump Cleaning	SOP-103	EC-ASC

Example: Evaporative Condenser

CHEMICAL ANALYSIS

Results expressed in parts per million

SAMPLE MARKED	RAW	1	2	3	4	5	6
Total Dissolved Solids (Microsiemens)		798	839	620	779	745	740
Suspended Solids (Appearance)							
pH Value		8.88	8.90	8.81	8.93	8.98	8.97
Total Hardness ($CaCO_3$)		230	230	160	200	240	240
Calcium Hardness ($CaCO_3$)							
Magnesium Hardness ($CaCO_3$)							
Sodium (Na)							
Silica (SiO_2)							
"P" Alkalinity ($CaCO_3$)		225					
"M" Alkalinity ($CaCO_3$)		[illegible]	250	200	225	225	200
"OH" Alkalinity ($CaCO_3$) / as "OH"							
Chlorides (Cl)							
Phosphate (PO_4)		15	20	20	15	15	15
Sulfite (SO_3)							
Sulfate (SO_4)							
Nitrite (NO_2)							
Nitrate (NO_3)							
Molybdate (MO)							
Iron (Fe)							
Copper (Cu)							
Cycles by Dissolved Solids							
Cycles by Total Hardness							
Cycles by Calcium Hardness							
Cycles by Chlorides							
Cycles by Sulfate							
Cycles by Silica							
Inhibitor Level							
Halogen (Free / Total)		.2	.3	.2	.4	.2	.2
Dispersant Level							

REMARKS: Towers - 1, 2, 4, 5, 6 - Conductivity and inhibitor and bromine low. Calebrated all Controllers and Filled all brominators.

Example: Evaporative Condenser

Evaporative Condenser	Frequency	Operating Procedure	Form
Visual Inspections	Weekly Inspection	SOP-101	EC-W
	Monthly Inspection	SOP-101	EC-M
	Annual Inspection	SOP-101	EC-A
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Maintenance	Quarterly Fan Bearings Service	SOP-103	EC-QFB
	Annual Sump Cleaning	SOP-103	EC-ASC

Example: Evaporative Condenser

A ABC Maintenance Annual Condenser Sump Maintenance 08/01/17

Toggle Sections | Documents (0) | Save | Delete | Print | Duplicate

WO #: * ABC WO Name: * Annual Condenser Sump Maintenance

Due Date
08/01/2017
Type
Maintenance
Completed Date

Frequency
Annual
WO Assigned to
Completed By

Work Description

B I U S | Font Family | Font Sizes

Clean Condenser 1 water sump and strainers. Follow the facility's Evaporative Condenser SOP and Confined Space Program when performing this maintenance activity.

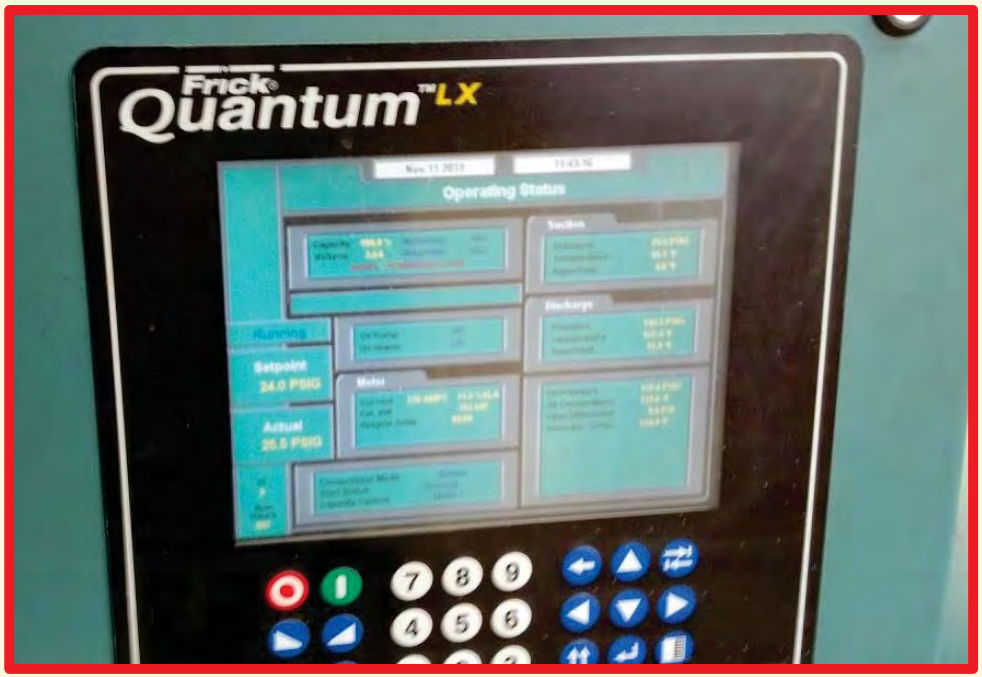
Keys to an Effective MI Program

1. *Access to equipment*
2. *Organized Program and Recordkeeping*
3. *Adequate Budget*
4. *Sufficient Manpower*
5. *Trained and Qualified Technicians*

Safety Systems: Overpressure Protection

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

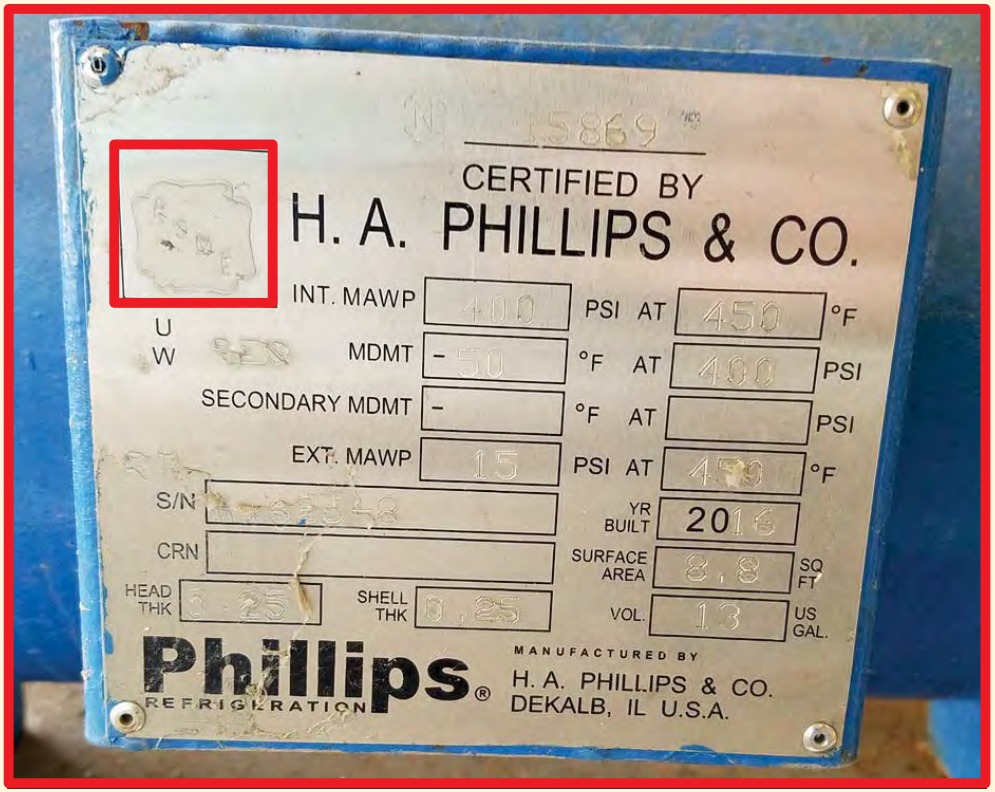
Pressure Limiting Devices



Rupture Discs

Relief Valves

Relief Valve Installation

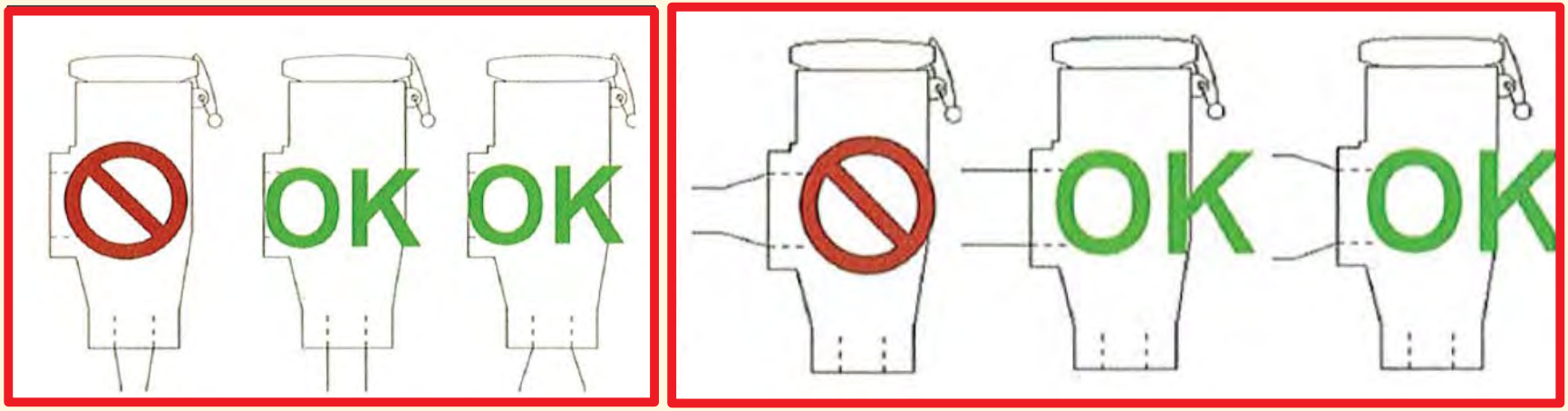


Relief Valve Installation

- **Single vs. Dual [2013 CMC §1117.2, 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

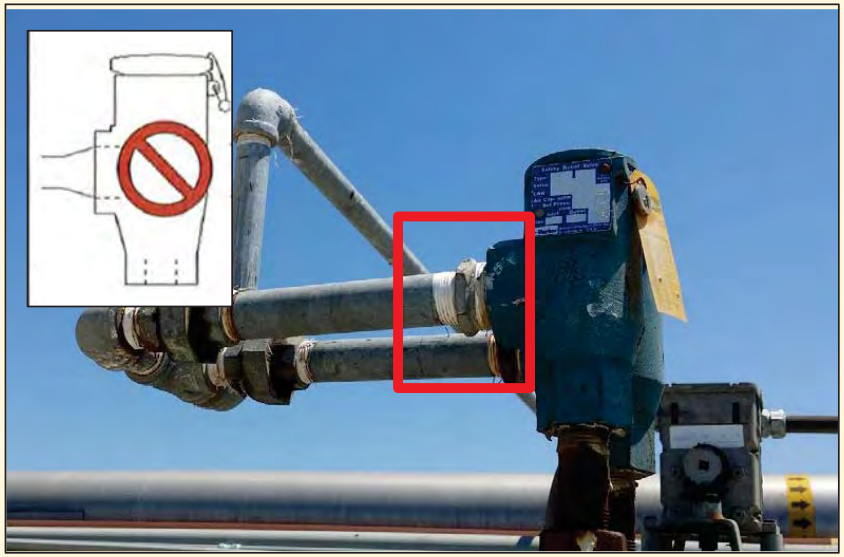
Relief Valve Installation

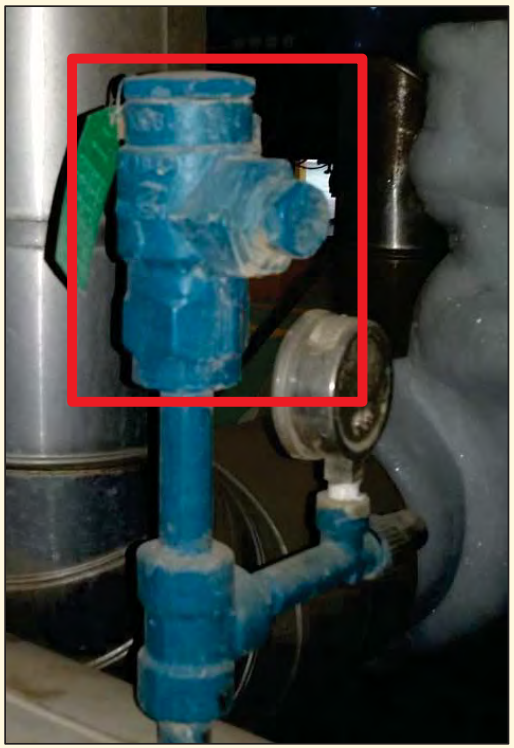
- **Piping [ANSI/IIAR 2-2014 §15.4]**



Relief Valve Installation

- **Piping [ANSI/IIAR 2-2014 §15.4]**





Relief Valve Replacement

Relief Valve Termination

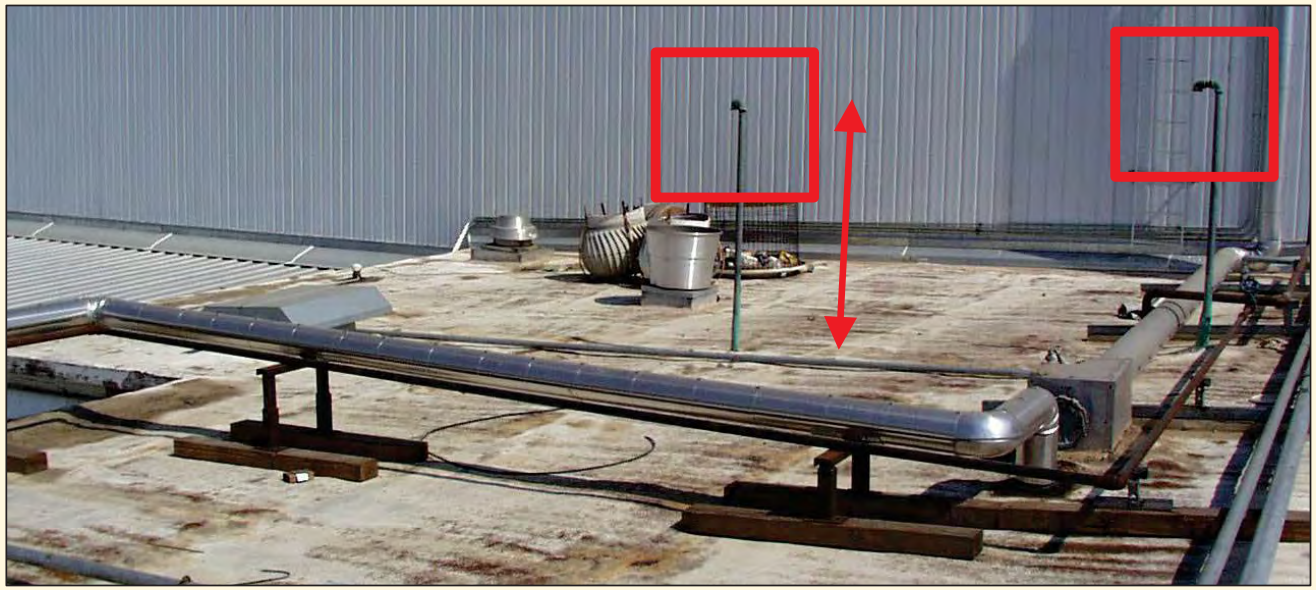
- **Ammonia Discharge [2013 CMC §1120.1]**

Relief Valve Termination

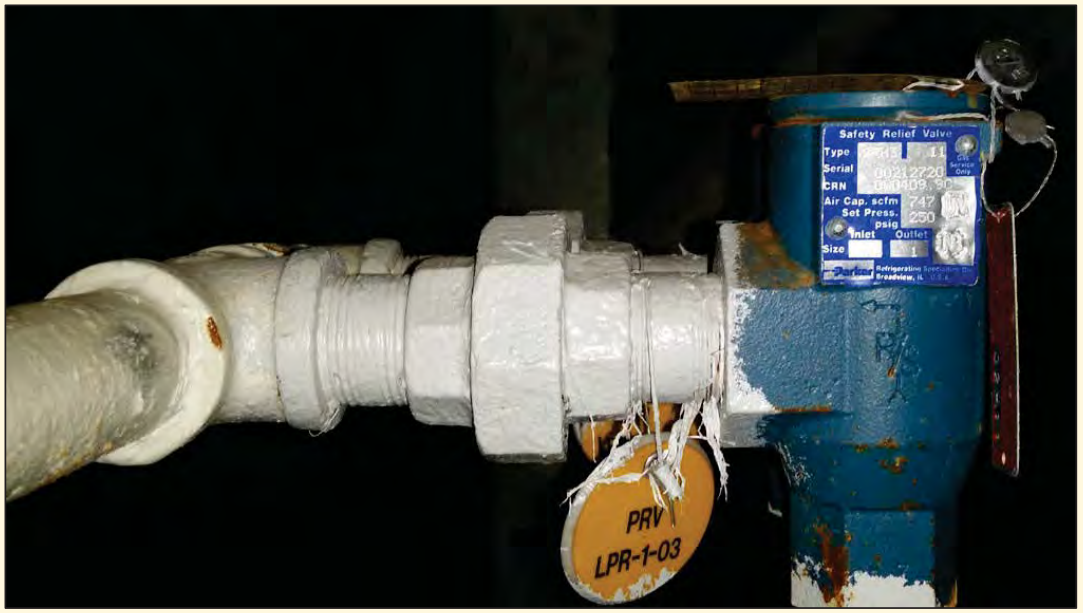
- **Atmospheric Discharge [ANSI/IIAR 2-2014 §15.5.1]**
  - Pipe sizing requirements [ANSI/IIAR 2-2014 §15.5.1.1.1]
  - Provision of draining moisture [ANSI/IIAR 2-2014 §15.5.1.6]
  - 20 ft from any window, ventilation intake, or personnel exit [ANSI/IIAR 2-2014 §15.5.1.2]
  - Not less than 15 feet above 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]**



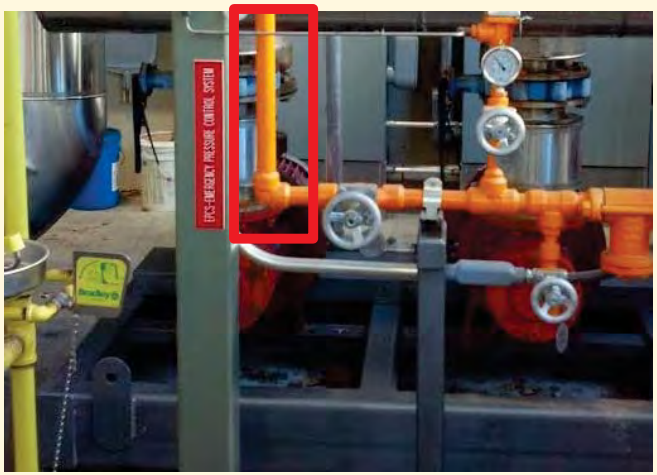
Relief Valve Discharge Piping

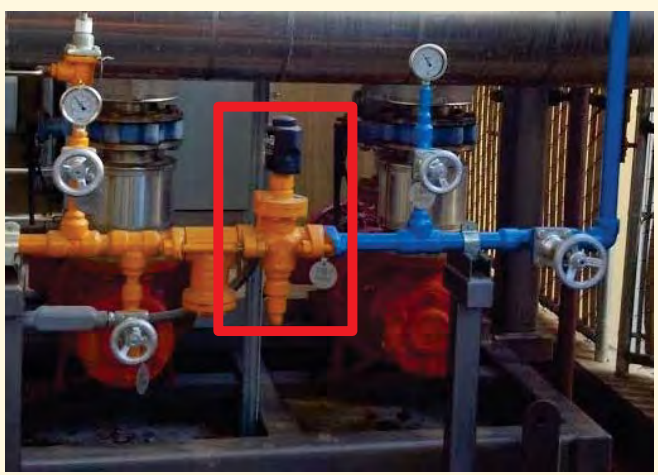


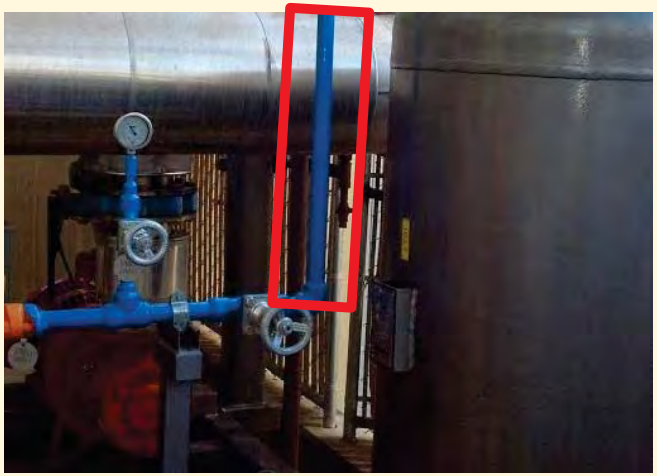
Set Pressure (psig)	Length (ft)	Nominal Pipe Size, NPS, DN										
		½	¾	1	1¼	1½	2	2½	3	4	5	6
		15	20	25	32	40	50	65	80	100	125	150
250	2	16.5	30.4	50.7	89.9	124	207	298	463	803	1268	1836
250	3	15.5	28.8	48.6	87.2	121	203	293	457	796	1260	1826
250	4	14.6	27.5	46.9	84.7	118	199	289	452	789	1251	1815
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

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

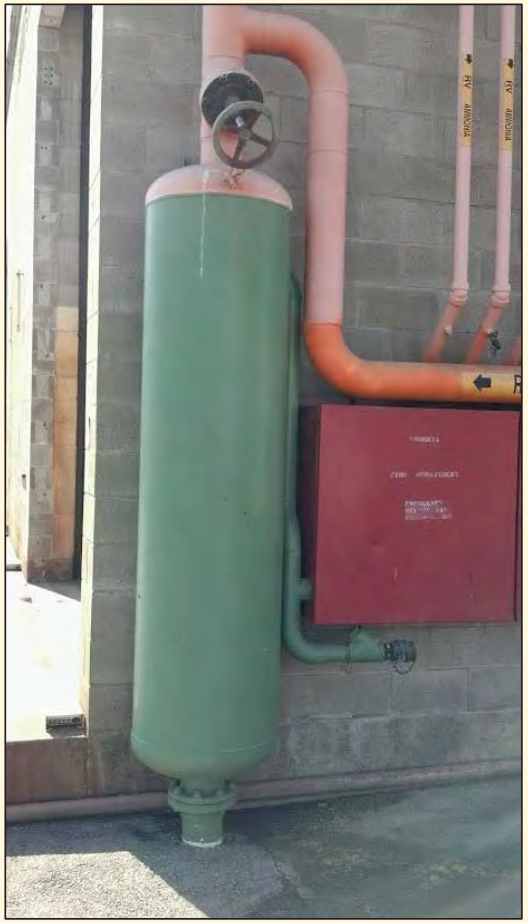
Emergency Pressure Control System







Emergency Control Box



Emergency Pressure Control System

Relief Vent Indicators / Vent Line Sensors

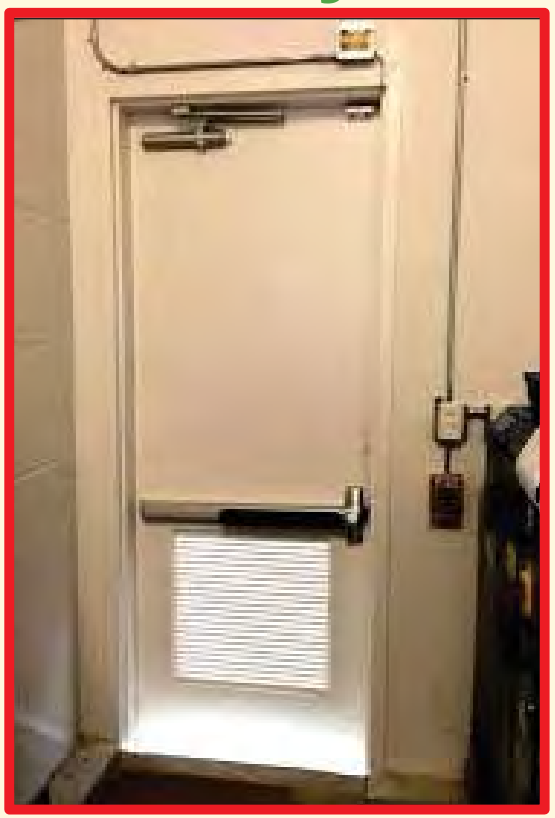
RAGAGEP: System Installation

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

Machinery Rooms

Machinery Room Access

Machinery Room Access



Machinery Room Storage

Machinery Room Open Flames

Eyewash and Safety Showers

Pipe

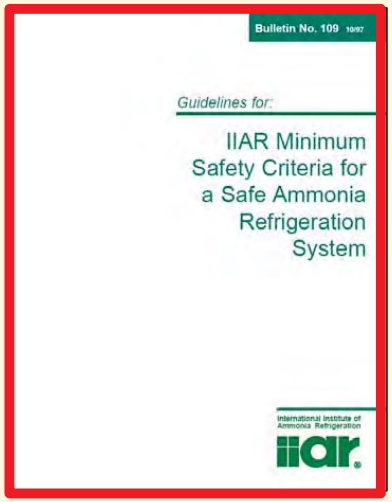
Insulation

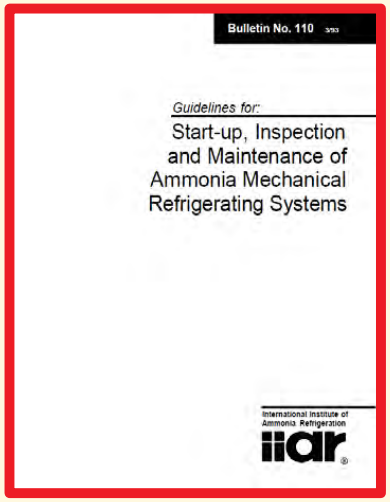
Insulation

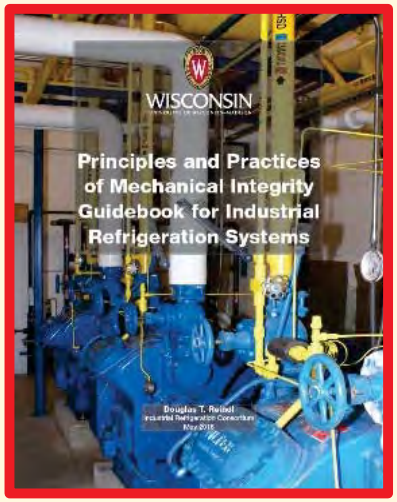
Insulation

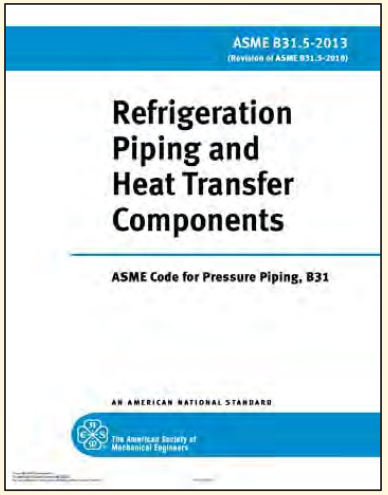
Pipe Wall Thickness

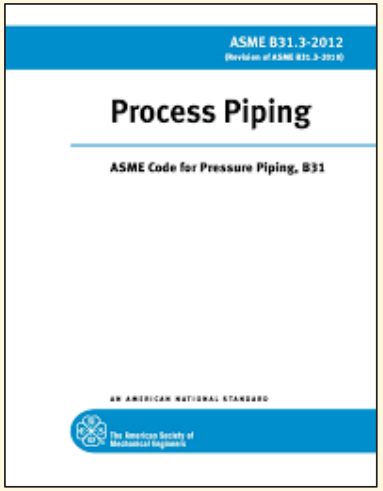
Key RAGAGEP documents











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	Wall thickness deviation from nominal	Alert Wall Thickness	Wall thickness deviation from nominal	Replace Wall Thickness	Wall thickness deviation from nominal
				(in)	(%)	(in)	(%)	(in)	(%)
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	$t \le 0.3 * t_{nom}$		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	$0.3 * t_{nom} \le t < t_{alert}$		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	$t_{alert} \le t < 0.875 * t_{nom}$		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	$t \ge 0.875 * t_{nom}$		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

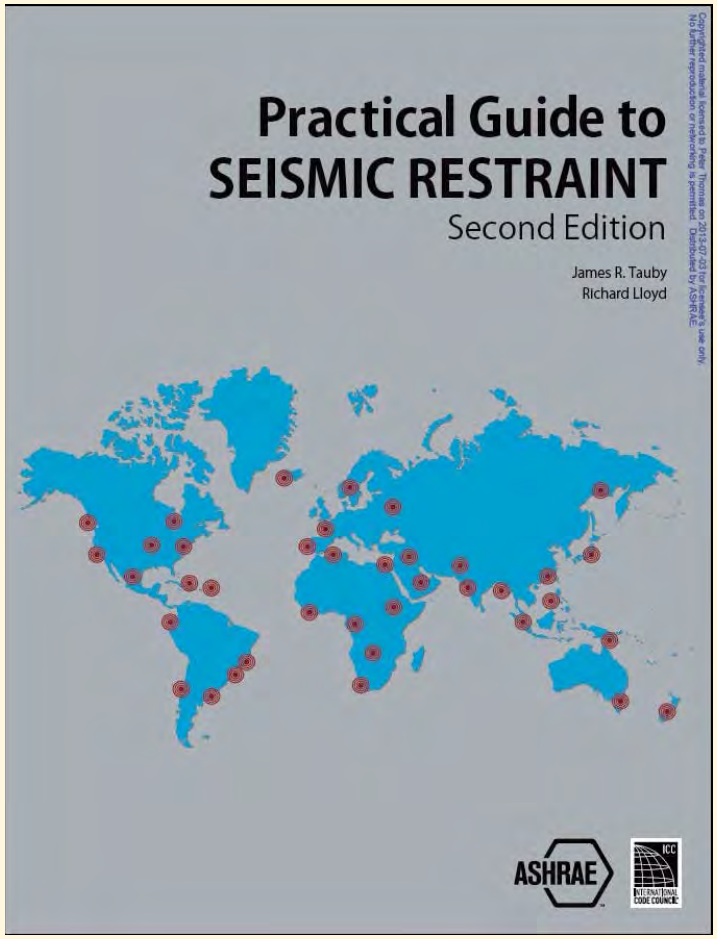
Pipe Supports

- 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



Trapeze Supports

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

Questions?

Stanislaus County Ammonia Refrigeration Training

Training Your Employees on the Ammonia System

Takeaways

- Understand the training requirements for the ammonia system
- Strategies to develop an *internal* training program
- Available resources

Training - Regulation Summary

Applicable employees must be trained at least every three (3) years (or when a change occurs) in the:

- (1) Process (2) Procedures (Operating & Maintenance) (3) Response

Every three (3) years in three (3) categories: Process, Procedures, Response

Training Requirements

All Facility Employees

- Chemical Safety & Awareness (ammonia safety)
- Emergency Response

Facility Operator/Maintenance

- Process Overview/Safety Information
- Operating Procedures
  - ➢ Operating the System
  - ➢ Mechanical Integrity/Maintenance

- Initial & refresher training
- Competency verification

Certificate of Successful Completion

Ron Bryan

has successfully completed the 5-hour *Ammonia Awareness and Refrigeration* training workshop on December 10, 2015 at California Controlled Atmosphere in Dinuba, CA.

Workshop included the following sessions:

- Ammonia Awareness
- Condenser Maintenance
- Control Valves
- Daily Checklist
- Refrigeration Cycle
- Temperature Probe Calibration
- SOPs Fit For Your Facility
- Non-Destructive Testing
- PSM Compliance
- Oil Draining
- Relief Valves
- System Balance Demo

CAL CA CALIFORNIA CONTROLLED ATMOSPHERE

Peter Thomas - Engineer

RESOURCE COMPLIANCE

Certificate No. 2753

Ammonia Awareness & Emergency Response Training

Properties of Ammonia

- **Color:** Colorless gas and liquid
- **Boiling Point:** -28.1ºF
- **Vapor Pressure:** 93 psig @ 60ºF
- **Vapor Density:** 0.60
- **Solubility:** Highly Soluble in Water (high affinity)
- **Smell: (Most recognizable)** Extremely pungent, irritating odor

Exposure Limits

- Permissible Exposure Limit (PEL): 25 ppm
- Short-Term Exposure Limit (STEL [15 min.]): 35 ppm
- Toxic Endpoint: 200 ppm
- Immediately Dangerous to Life or Health (IDLH): 300 ppm

First Aid Procedures

Health Effects

Irritation, chemical burns, eye damage and fatal in high concentrations.

Inhalation - First Aid

Depending Remove from exposure area. If breathing has stopped administer artificial respiration.

Skin/Eye Contact - First Aid

Flush with water for 15 minutes and contact a physician.

Evacuation


STAGING AREA 3
PARKING LOT
REEDLEY LUMBER
PLANT 4
1750 16TH STREET
H STREET
16TH AVENUE
STAGING AREA 1
G STREET
PLANT 3
1750 16TH STREET
PLANT 1
1625 G STREET
PACK AREA
ROOM 6
ROOM 5
PLANT 2
1625 G STREET
ROOM 4
MACHINE SHOP
AMMONIA TANK
PROPANE TANK
FIRE EXTINGUISHER
FIRE HYDRANT
FIRST AID
EYEWASH SHOWER
EYEWASH STATION
FORKLIFT CHARGING
PROCESS 1
PROCESS 2
PROCESS 3
PROCESS 4

AMMONIA SAFETY

IF YOU SMELL AMMONIA	IMMEDIATELY LEAVE THE AREA
IF YOU INHALE AMMONIA	IMMEDIATELY SEEK FRESH AIR AND MEDICAL ATTENTION IF NECESSARY
IF YOU HAVE SKIN OR EYE CONTACT WITH AMMONIA	IMMEDIATELY FLUSH AFFECTED AREA WITH WATER FOR A MINIMUM OF 15 MINUTES *Note: DO NOT remove clothing exposed to liquid ammonia until thawed by flushing with water.*
IF YOU SEE AN AMMONIA CLOUD	IMMEDIATELY EXIT THE BUILDING OR AREA AND MOVE TO A DESIGNATED LOCATION

! IN ALL CASES REPORT TO YOUR SUPERVISOR AND FOLLOW YOUR FACILITY EMERGENCY ACTION PLAN

GLOBAL COLD CHAIN ALLIANCE

alliance

Through its Alliance with OSHA, the Global Cold Chain Alliance developed this poster for informational purposes only. It does not necessarily reflect the official views of OSHA or the U.S. Department of Labor. Feb. 2011

SEGURIDAD CON EL AMONIACO

SI HUELES AMONÍACO	RETÍRESE DE ESA ÁREA INMEDIATAMENTE BUSQUE AIRE FRESCO
SI HA INHALADO AMONIACO	INMEDIATAMENTE Y ATENCIÓN MEDICA DE SER NECESARIO
SI EL AMONIACO TIENE CONTACTO CON SU PIEL U OJOS	INMEDIATAMENTE ENJUAGUE EL ÁREA AFECTADA CON AGUA POR UN MÍNIMO DE 15 MINUTOS (NOTA: NO REMUEVA LA ROPA QUE HA SIDO EXPUESTA AL AMONIACO LÍQUIDO HASTA QUE SE DERRITA AL ENJUAGARLO CON AGUA)
EXIT SI MIRA UNA NUBE DE AMONIACO	SALGA DEL EDIFICIO INMEDIATAMENTE O DEL ÁREA Y MUÉVASE HACIA EL LUGAR DESIGNADO

! EN TODOS LOS CASOS REPÓRTALO A TU SUPERVISOR Y SIGUA EL PLAN DE EMERGENCIA DEL EDIFICIO.

RESOURCE COMPLIANCE

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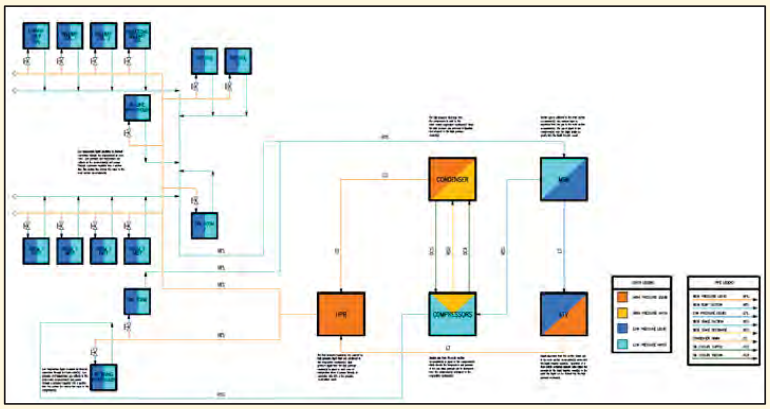
Peter Thomas - Engineer

RESOURCE COMPLIANCE

Certificate No. 2753

Process Safety Information

PSI Elements



- Safety Data Sheet (SDS)
- Block Flow Diagram (BFD)
- Process Chemistry
- Maximum Intended Inventory
- Safe Operating Limits & Consequences of Deviation
- Materials of Construction
- Piping & Instrumentation Diagrams (P&IDs)

Process Safety Information

PSI Elements

- Electrical and Safety Classifications
- Relief System Design
- Ventilation System Design
- Design Codes and Standards
- Material and Energy Balances
- Safety Systems
- Electrical Supply and Distribution Systems

Training Requirements

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RESOURCE COMPLIANCE

Certificate No. 2753

Operators must…

- Know the location of the Operating Procedures
- Know how to navigate and reference the Operating Procedures
- Know the hazards of the process
- Be competent in the Operating Procedures

- **'…each employee involved in operating a process has received and understood the training.'**

Sample Compressor Operating Procedure – Normal Operations

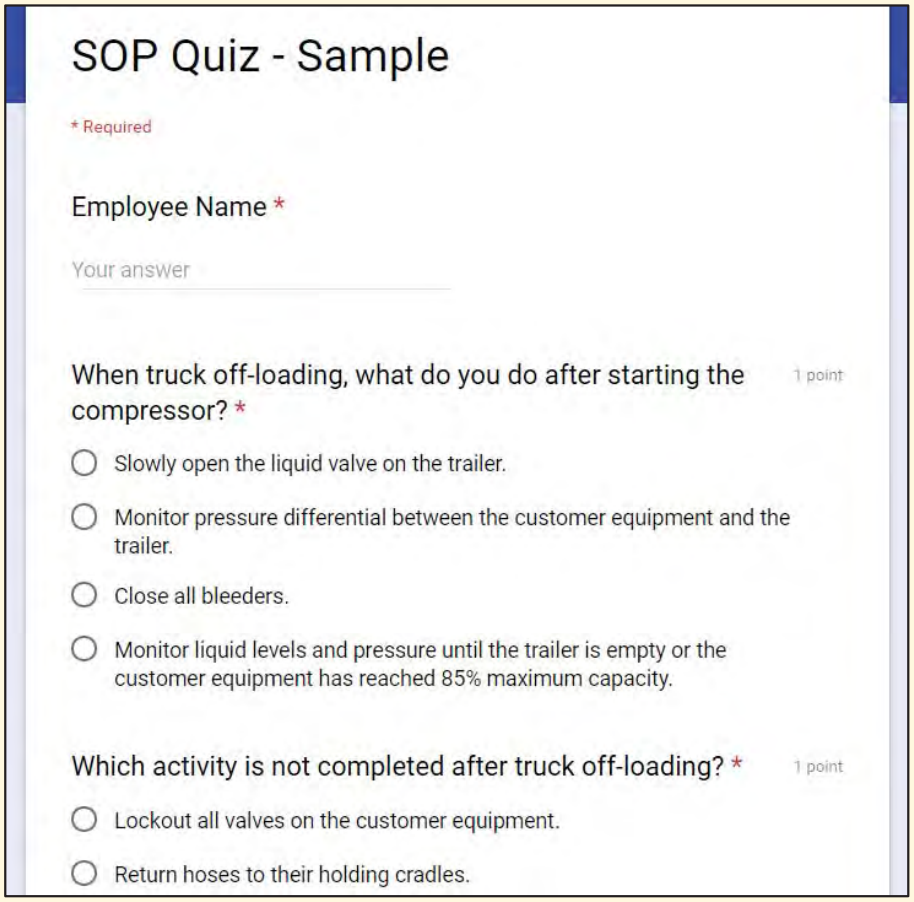
Normal Operations

1. During normal operations, the compressor will automatically load and unload based on suction pressure.
2. During low load conditions, the compressor may enter *'Standby'* mode until the system load requires it to operate at some capacity.
3. Visually inspect the compressor at least twice per shift for any problems such as vibration, excessive pressure, ammonia leaks, or lubrication oil leaks.
4. The following *minimum* operating parameters must be checked to ensure that they are within the desired range:
    a. Suction Pressure
    b. Discharge Pressure
    c. Oil Pressure
    d. Oil Temperature
5. Complete the daily log as required by the facility *Mechanical Integrity* program.

How do you know your operator is competent in the procedure?

“Competency is King”

Create a quiz and test them



SOP Quiz - Sample

* Required

Employee Name *

Your answer

When truck off-loading, what do you do after starting the compressor? * 1 point

- Slowly open the liquid valve on the trailer.
- Monitor pressure differential between the customer equipment and the trailer.
- Close all bleeders.
- Monitor liquid levels and pressure until the trailer is empty or the customer equipment has reached 85% maximum capacity.

Which activity is not completed after truck off-loading? * 1 point

- Lockout all valves on the customer equipment.
- Return hoses to their holding cradles.

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RESOURCE COMPLIANCE

Certificate No. 2753

Mechanical Integrity/Maintenance Training

- Daily Operations Checklist
- Monthly Inspection
- Annual Inspection
- 5-Year Inspection

Daily Operations Checklist
Ammonia Refrigeration System

		Date							
		Time							
Gauge Board	Suction Pressure	33 - 50 psig							
	Discharge Pressure	120 -195 psig							
Screw Compressor #1	Running	Yes/No							
	Run Time	Hours							
	Oil Level	Sight glass should be 1/2 full							
	Alarms	Yes/No - check microprocessor							
	Suction Temperature	19°F - 34°F							
	Suction Pressure	33 psig - 50 psig							
	Discharge Pressure	120 psig - 195 psig							
	Oil Temperature	120°F - 170°F							
	Oil Filter Pressure	60 psig - 90 psig							
	Motor Amps	A							
	Slide Valve	%							
Condenser #1	Fans Running	Yes/No							
	Pump Running	Yes/No							
	Belts	Too loose or too tight?							
Liquid Recirculator	Visual Inspection	Free from unusual vibration, sounds, and smells.							
Pilot Receiver	Visual Inspection	Free from unusual vibration, sounds, and smells.							
Ice Generator	Visual Inspection	Free from unusual vibration, sounds, and smells.							
		Initials							

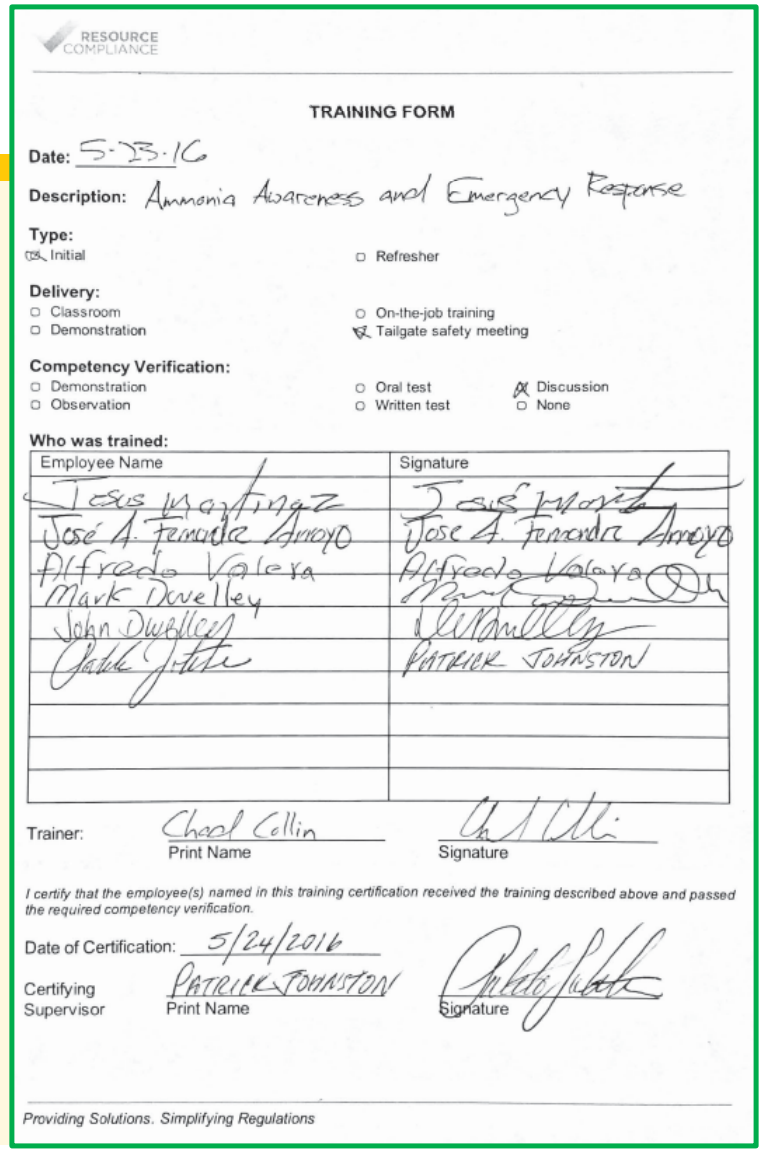
Strategies to Train Employees

- Do you have someone who coordinates all training for the company?
- Setup a training schedule
- Group trainings together (ex. Chemical Awareness & Emergency Response)
- Train all employees during initial orientation
- Annual refresher built into company training program
- Test for competency

RESOURCE COMPLIANCE

Documentation

If it wasn't documented…it didn't happen



RESOURCE COMPLIANCE

TRAINING FORM

Date: 5-13-16

Description: Ammonia Awareness and Emergency Response

Type:
☒ Initial ☐ Refresher

Delivery:
☐ Classroom ☐ On-the-job training
☐ Demonstration ☒ Tailgate safety meeting

Competency Verification:
☐ Demonstration ☐ Oral test ☒ Discussion
☐ Observation ☐ Written test ☐ None

Who was trained:

Employee Name	Signature
Jesus Martinez	Jesus Martinez
José A. Fernandez Arroyo	José A. Fernandez Arroyo
Alfredo Valera	Alfredo Valera
Mark Dwelley	
John Dwelley	
Patrick Johnston	PATRICK JOHNSTON

Trainer: Chad Collin (Print Name) (Signature)

I certify that the employee(s) named in this training certification received the training described above and passed the required competency verification.

Date of Certification: 5/24/2016

Certifying Supervisor: PATRICK JOHNSTON (Print Name) (Signature)

Providing Solutions. Simplifying Regulations

Useful Training Resources

- Chemical Safety Days – www.cvcsd.org (Turlock – November 2, 2017)
- Refrigerating Engineers & Technicians Association (RETA) classes and certification – www.reta.com
- Local RETA chapters (San Joaquin Valley)
- Sacramento Safety Day (typically April)

Useful Training Resources

- Resource Compliance Blog – www.resourcecompliance.com/blog
- Garden City Ammonia Program (GCAP) – www.ammoniatraining.com
- Contractor Training
- Consultants

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