Ammonia Refrigeration RAGAGEP

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

Citation 1 Item 2  Type of Violation: Serious


On or about ___, the employer did not document that the equipment complies 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 the “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 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

- International Institute of Ammonia Refrigeration (iiar)
- American National Standards Institute (ANSI)
- International Code Council (ICC)
- International Association of Plumbing and Mechanical Officials (IAPMO)
- American Society of Mechanical Engineers (ASME)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
IIAR Literature

- IIAR Bulletin No. 110 Guidelines for: Start-up, Inspection and Maintenance of Ammonia Mechanical 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. 116 Guidelines for: Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock
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

- Bulletin No. 114 (March 2014)
  Guidelines for:
  Identification of Ammonia Refrigeration Piping and System Components

- Bulletin No. 109 (2017)
  Guidelines for:
  IIAR Minimum Safety Criteria for a Safe Ammonia Refrigeration System

- Bulletin No. 110
  Guidelines for:
  Start-up, Inspection and Maintenance of Ammonia Mechanical Refrigerating Systems
IIAR Standard 2

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

1974-78

1984

1999

2008

2014
IIAR 2 vs. ASHRAE 15

IIAR 2: American National Standard
Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems

ASHRAE 15-2013
Safety Standard for Refrigeration Systems
Other RAGAGEP Documents

- 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.
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.**
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.
Conflicts in RAGAGEP

- Maximum Length of Relief Valve Discharge Piping
Conflicts in RAGAGEP

Maximum Length of Relief Valve Discharge Piping

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

VS.

2012 IMC: \( L = \frac{0.2146d^5(P_0^2 - P_2^2)}{f C_r^2} - \frac{d \times \ln(P_0/P_2)}{6f} \)
Conflicts in RAGAGEP

Relief Valve Discharge Termination
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.
**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
  o No machinery room modifications required
  o New room must comply with 2012 IMC and ANSI/IIAR 2-2008 Addendum B
  o 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)

<table>
<thead>
<tr>
<th>What If</th>
<th>Scenarios</th>
<th>Consequences</th>
<th>Safety Likelihood</th>
<th>Safeguards</th>
</tr>
</thead>
</table>
| 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 | 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. |
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.
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]
  o Pressure vessels between 3ft³ and 10ft³ are permitted to use a single relief valve
  o Pressure vessels greater than 10ft³ 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
\[ L = \frac{0.2146d^5(P_0^2 - P_2^2)}{fC_r^2} - \frac{d \times \ln(P_0/P_2)}{6f} \]

<table>
<thead>
<tr>
<th>Set Pressure (psig)</th>
<th>Length (ft)</th>
<th>Nominal Pipe Size, NPS, DN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>½</td>
<td>¼</td>
</tr>
<tr>
<td>250</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>250</td>
<td>15.5</td>
<td>28.8</td>
</tr>
<tr>
<td>250</td>
<td>14.6</td>
<td>27.5</td>
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<tr>
<td>250</td>
<td>13.8</td>
<td>26.4</td>
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<td>13.2</td>
<td>25.4</td>
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<td>250</td>
<td>12.2</td>
<td>23.6</td>
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<td>250</td>
<td>11.3</td>
<td>22.2</td>
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<td>10.0</td>
<td>19.6</td>
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<td>15.1</td>
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<td>250</td>
<td>6.5</td>
<td>13.4</td>
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<tr>
<td>250</td>
<td>5.4</td>
<td>11.3</td>
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<td>250</td>
<td>4.3</td>
<td>8.9</td>
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<tr>
<td>250</td>
<td>3.4</td>
<td>7.1</td>
</tr>
<tr>
<td>250</td>
<td>2.7</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Emergency Pressure Control System
Emergency Control Box
Emergency Pressure Control System
Relief Vent Indicators / Vent Line Sensors
Ventilation

Installation
Ventilation Control
Detection
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
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

- 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

**MACHINERY ROOM – ELEVATION VIEW**

**WARNING**

When alarms are activated, ammonia has been detected:
1. Leave room immediately
2. Do not enter except by trained and authorized personnel
3. Do not enter without personal protective equipment
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?


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 ENTRANCE
- POWERED INDEPENDENTLY OF EQUIPMENT AND SHUT DOWN CONTROLS
- POWER FAILURE TO SIGNAL A MONITORED LOCATION
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

- COLD ROOMS
- RECIRCULATOR ROOM
- MACHINERY ROOM

- 25 PPM
- 150 PPM
- 40,000 PPM

GUARD STATION
Machinery Room Storage
Machinery Room Open Flames
Eyewash and Safety Showers
Pipe
Pipe
Insulation
Insulation
Insulation
Insulation
Pipe Wall Thickness

Key RAGAGEP documents:

- Bulletin No. 100: IIAR Minimum Safety Criteria for a Safe Ammonia Refrigeration System
- Bulletin No. 110: Start-up, Inspection and Maintenance of Ammonia Mechanical Refrigerating Systems
- Wisconsin Principles and Practices of Mechanical Integrity Guidebook for Industrial Refrigeration Systems
- ASME B31.5-2018: Refrigeration Piping and Heat Transfer Components
- ASME B31.3-2018: Process Piping
# IRC MI Guidebook

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

<table>
<thead>
<tr>
<th>Nominal Size (in)</th>
<th>Min Nom. Wall Thickness (in)</th>
<th>Min Wall thickness deviation from normal (in)</th>
<th>Alert Wall Thickness (in)</th>
<th>Alert Wall thickness deviation from normal (in)</th>
<th>Replace Wall Thickness (in)</th>
<th>Replace Wall thickness deviation from normal (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>0.147</td>
<td>0.129 (12.5)</td>
<td>0.090 (46.6)</td>
<td>0.044 (70.0)</td>
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<td></td>
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<tr>
<td>3/4&quot;</td>
<td>0.154</td>
<td>0.135 (12.5)</td>
<td>0.090 (48.1)</td>
<td>0.048 (70.0)</td>
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<tr>
<td>1&quot;</td>
<td>0.179</td>
<td>0.157 (12.5)</td>
<td>0.085 (55.3)</td>
<td>0.054 (70.0)</td>
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<td>1-1/4&quot;</td>
<td>0.182</td>
<td>0.167 (12.5)</td>
<td>0.089 (58.1)</td>
<td>0.057 (70.0)</td>
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<td>1-1/2&quot;</td>
<td>0.200</td>
<td>0.175 (12.5)</td>
<td>0.090 (56.0)</td>
<td>0.060 (70.0)</td>
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<tr>
<td>2&quot;</td>
<td>0.216</td>
<td>0.157 (12.5)</td>
<td>0.100 (55.1)</td>
<td>0.046 (70.0)</td>
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<td>2-1/2&quot;</td>
<td>0.203</td>
<td>0.178 (12.5)</td>
<td>0.100 (50.7)</td>
<td>0.061 (70.0)</td>
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<td>3&quot;</td>
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<td>0.189 (12.5)</td>
<td>0.110 (49.1)</td>
<td>0.065 (70.0)</td>
<td></td>
<td></td>
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<tr>
<td>4&quot;</td>
<td>0.237</td>
<td>0.207 (12.5)</td>
<td>0.120 (49.4)</td>
<td>0.071 (70.0)</td>
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<td></td>
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<tr>
<td>5&quot;</td>
<td>0.258</td>
<td>0.226 (12.5)</td>
<td>0.120 (53.5)</td>
<td>0.077 (70.0)</td>
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<td>6&quot;</td>
<td>0.280</td>
<td>0.245 (12.5)</td>
<td>0.130 (53.8)</td>
<td>0.084 (70.0)</td>
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<tr>
<td>8&quot;</td>
<td>0.322</td>
<td>0.282 (12.5)</td>
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<td>10&quot;</td>
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<tr>
<td>16&quot;</td>
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<td>18&quot;</td>
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<td>0.226 (39.1)</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Flag</th>
<th>Action Required/Comments</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 ≤ 0.3 * (t_{w} )</td>
<td></td>
<td>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.</td>
<td>Gerber et al (1992)</td>
</tr>
<tr>
<td>2</td>
<td>0.3 * (t_{w} ) ≤ t ≤ (t_{b} )</td>
<td></td>
<td>Piping below the alert wall thickness requires a more detailed engineering analysis to determine (t_{b} ) 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 &lt; t_{b} ), 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.</td>
<td>API RP 574 (2009) &amp; ASME B31.5 (2013)</td>
</tr>
<tr>
<td>3</td>
<td>(t_{b} ) ≤ t ≤ 0.875 * (t_{w} )</td>
<td></td>
<td>If the measured wall thickness, (t ), is less than nominal minus the mill tolerance but greater than (t_{b} ), the piping can continue operation. As the wall thickness approaches (t_{b} ), consider increased inspection frequency.</td>
<td>API RP 574 (2009) &amp; ASME B31.5 (2013)</td>
</tr>
<tr>
<td>4</td>
<td>t ≥ 0.875 * (t_{w} )</td>
<td></td>
<td>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.</td>
<td>Original design per ASME B31.5 (2013)</td>
</tr>
</tbody>
</table>
Pipe Supports
Pipe Supports
Pipe Supports
### Pipe Supports

- **ANSI/IIAR 2-2014 Appendix F**

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Maximum Span</th>
<th>Minimum Rod Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1</td>
<td>7</td>
<td>1/8</td>
</tr>
<tr>
<td>1-⅜ - 1-1/2</td>
<td>9</td>
<td>3/8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>2-1/2</td>
<td>10</td>
<td>1/2</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>1/2</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>5/8</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>5/8</td>
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<td>3/4</td>
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<td>8</td>
<td>19</td>
<td>7/8</td>
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</tr>
<tr>
<td>12</td>
<td>23</td>
<td>7/8</td>
</tr>
</tbody>
</table>
Equipment Anchors
Supports and Anchorage
Anchorage
Trapeze Supports
Safe Access
Safe Access
Service Provision

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

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