Corrosion Under Insulation

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INTRODUCTION

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- Maintenance Technology Department (Mechanical Integrity Team)

- 38+yrs at Dow
- NDT & Mechanical Integrity Subject Matter Expert.
- Member of GMISS Steering team
- Leading the NDT & In-Plant Inspection TST

INTRODUCTION TO CUI

CUI WAKE-UP CALL

- Dow's Process Safety performance has been good.
- Corporate-wide mechanical integrity programs in place since the 1960's
- Global Mechanical Integrity Safety Standard (GMISS) called for piping inspections consistent with API 570 since the 2001 or earlier for piping in highly hazardous services.
- A few earlier leaks and close calls convinced us that more explicit guidance needed in our standard – so we updated in 2004.

A VERY SIGNIFICANT "NEAR MISS"

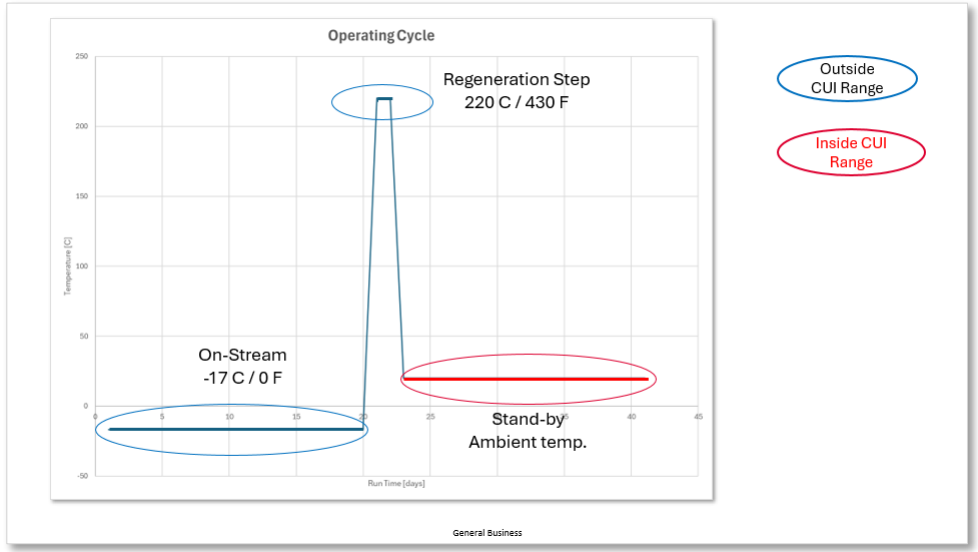
- Sudden failure of a 8 inch carbon steel high pressure hydrocarbon line due to Corrosion Under Insulation

GOOD FORTUNE???

- Fortunately, the pipe failed with such force….that the pipe bent in two locations such that it essentially self-sealed to line willed with ethylene and other hydrocarbons

THE PIPING SERVICE

- Piping was a 30 year old,
- Schedule 20, carbon steel
- Regeneration line to a cracked gas dryer of an ethylene plant (one of two parallel drying trains).
- Due to the regeneration service, the piping alternates between three different conditions, and the location of failure was where operating temperatures cause frequent or continuous condensation and re-evaporation of atmospheric moisture:
  - Regeneration condition (4 bar, 220° C)
  - On stream time: 20 days (30 bar, -17° C)
  - Regeneration time: 24 hrs (220° C)
  - Standby: 19 days (ambient temperature)



CLASSIC LOCATION FOR CUI

Location of pipe failure.

Note that the transition from external icing to no icing at this location when the line is not in service. This established a humid boundary condition, which is a classic CUI susceptible location.

Root Causes / Lessons Learned

A number of key root causes were identified in the root cause investigation from this incident.

Cause #1 - Inadequate Inspection in 2004 and earlier

Not according to e.g. API510 / 570

Insufficient Insulation removal / NDT Inspection

Cause #2 – Operating conditions unknown

Mechanical Integrity Programs can not rely solely upon contract inspectors and need adequate involvement of plant personnel familiar with plant operations.

Root Causes / Lessons Learned

Actions coming out of the RCI

Training of all involved disciplines

- Inspection Personnel
- Operations Personnel
- Maintenance Personnel

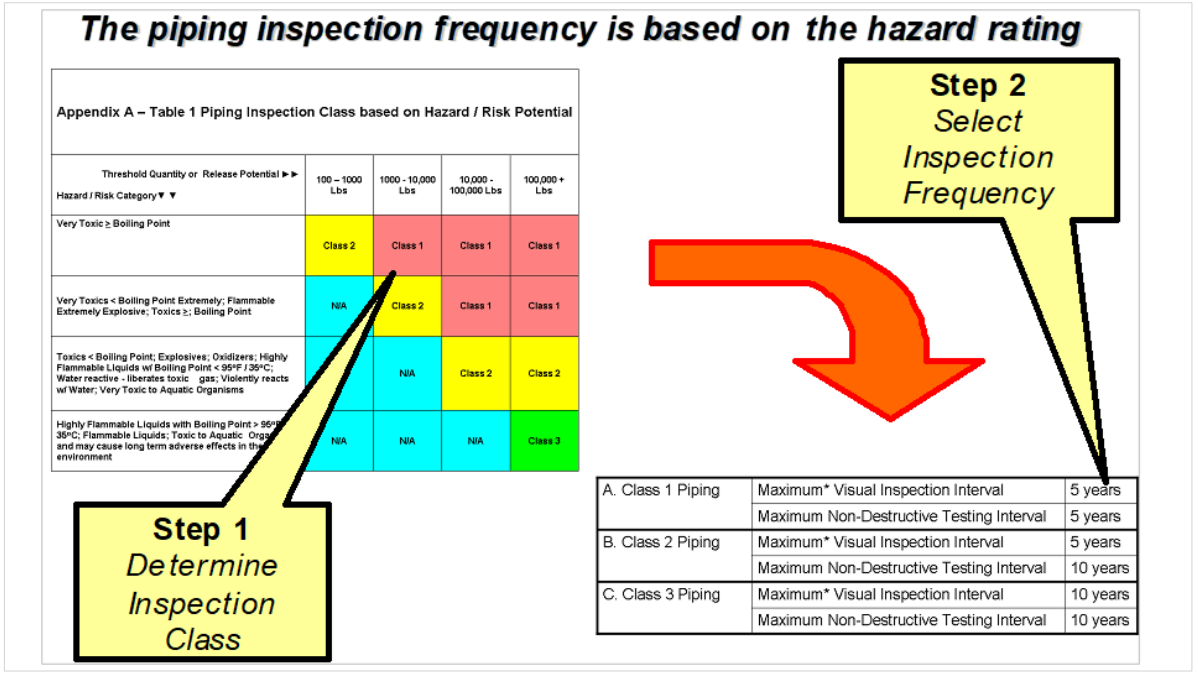
Roles & Responsibilities

CUI Emphasis Program

- Global Oversight /Reporting
- GMISS audits

LESSONS LEARNED #1

- The 2004 version of the Dow mechanical integrity safety standard provided much greater clarity regarding, insulation to be removed, and CUI susceptible regions per API-570.
  Examples of figures or text from the 2004 standard are below:



LESSONS LEARNED #1 (CONT.)

Key requirements copied directly from API-570:

Piping Class	Approximate amount of CUI Inspection by NDE or Insulation Removal at "Suspect Areas" on piping systems within "Susceptible Temperature Ranges."	Approximate amount of follow-up examination with NDE or Insulation Removal in areas with Damaged Insulation on piping systems within "Susceptible Temperature Ranges."
1	50 % of suspect areas	75 % of area of damaged insulation
2	33 % of suspect areas	50 % of area of damaged insulation
3	10 % of suspect areas	25 % of area of damaged insulation

Susceptible Temperature Ranges – API 570 Piping Inspection Code, Section 5.3.3.1 e, f & h:

e. Carbon steel piping systems, including those insulated for personnel protection, operating between 25°F–250°F (–4°C–120°C). CUI is particularly aggressive where operating temperatures cause frequent or continuous condensation and re-evaporation of atmospheric moisture.

f. Carbon steel piping systems that normally operate in-service above 250°F (120°C) but are in intermittent service.

h. Austenitic stainless steel piping systems operating between 150°F–400°F (65°C–204°C). (These systems are susceptible to chloride stress corrosion cracking.)

Suspect Areas – API 570 Piping Inspection Code, Section 5.3.3.2

The areas of piping systems listed in 5.3.3.1 may have specific locations within them that are more susceptible to CUI, including the following:

a. All penetrations or breaches in the insulation jacketing systems, such as: 1) Deadlegs (vents, drains, and other similar items), 2) Pipe hangers and other supports, 3) Valves and fittings (irregular insulation surfaces), 4) Bolted-on pipe shoes and 5) Steam tracer tubing penetrations.

b. Termination of insulation at flanges and other piping components.

c. Damaged or missing insulation jacketing.

d. Insulation jacketing seams located on the top of horizontal piping or improperly lapped or sealed insulation jacketing.

e. Termination of insulation in a vertical pipe.

f. Caulking that has hardened, has separated, or is missing……..

g. Bulges or staining of the insulation or jacketing system or missing bands. (Bulges may indicate corrosion product buildup.)

h. Low points in piping systems that have a known breach in the insulation system, including low points in long unsupported piping runs.

i. Carbon or low-alloy steel flanges, bolting, and other components under insulation in high-alloy piping systems.

j. Locations where insulation plugs have been removed to permit piping thickness measurements on insulated piping should receive particular attention. These plugs should be promptly replaced and sealed. Several types of removable plugs are commercially available that permit inspection and identification of inspection points for future reference.

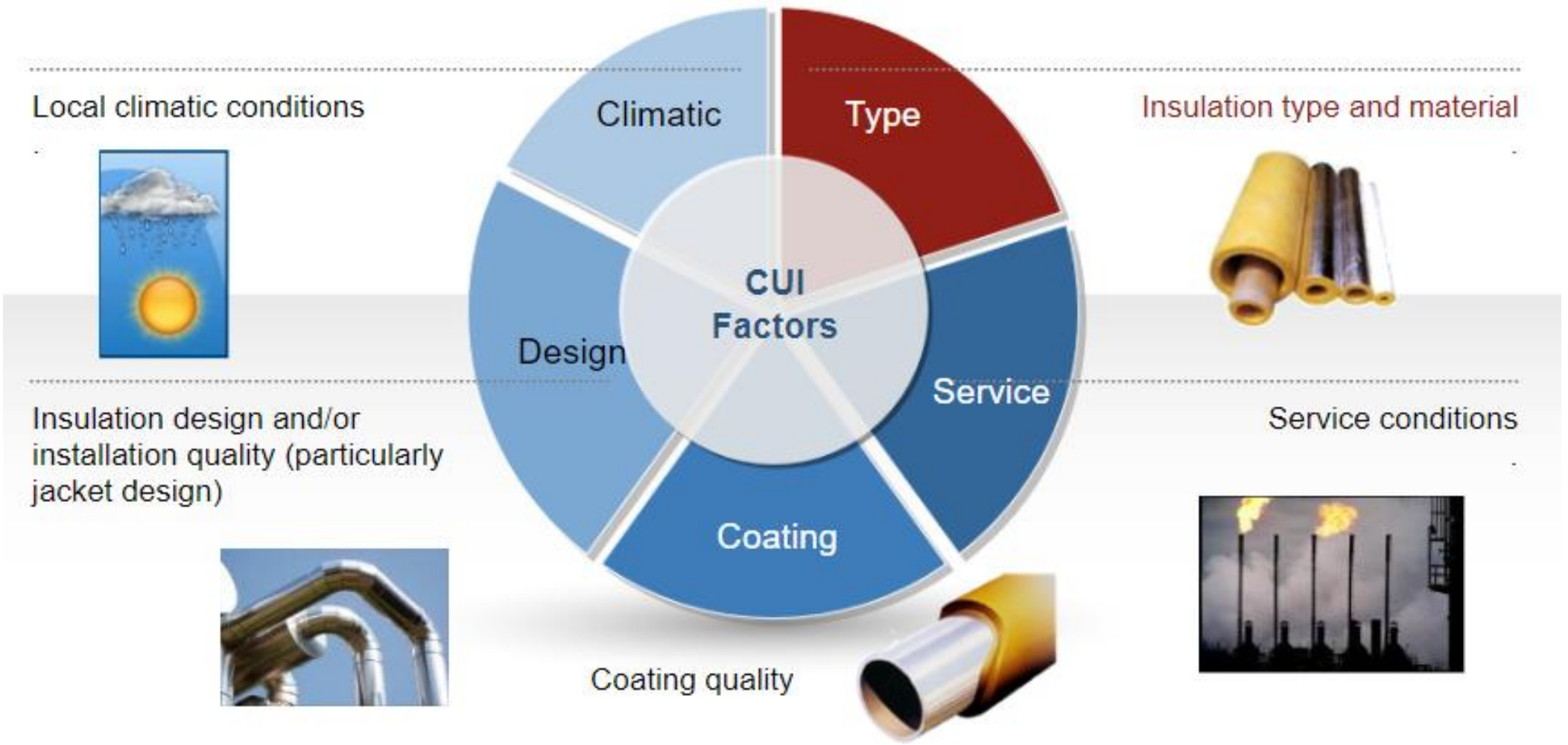
CUI MANAGEMENT

CUI Management – Industry Challenge

- CUI is a significant problem for industry.
- For process plant, most common external damage mechanism.
- Primarily associated with carbon steel and stainless-steel components.
- Poses a major safety risk if left unchecked.
- Corrosion is hidden, often localised and rate can be unpredictable.
- Substantial cost to business and industry to address and manage this damage mechanism.
  - Safety and reputation
  - Financial impact
  - Unplanned events/ repairs

CUI Examples

FACTORS THAT MAY AFFECT THE LIKELIHOOD OF CUI



CUI MANAGEMENT STRATEGY - CURRENT

- Industry standards e.g. API510, API570, HOIS-G-023, etc. and best practices used to manage strategy for addressing this damage mechanism. These determine:
  - The inspection interval (time based)
  - Scope – % susceptible locations & extent of insulation removal for inspection confidence.
  - Actions to take when corrosion is found.
- Access to conduct effective inspections is not always easy.
- Inspection of plant & piping is extremely expensive and time consuming.
  - Scope creep based on findings
  - Repair impact (cost & time)
  - Production delays and downtime
- Experience and history indicate where we should look…… but detecting and targeting where CUI **is** taking place is a problem.

CUI MANAGEMENT – FUTURE CHALLENGE

- Industry is looking to reduce safety risk and costs associated with CUI management (inspection and repair).
- Utilise predictive technology and methodology for CUI.
- Use data to define inspection scope and interval, to drive:
  - Intervention (inspection) where and when required.
  - At locations where damage or potential for damage is detected.

- Adopt technology and methodology into industry standards and best practice
  - Evaluate the use of Sensor Technology options in global standards

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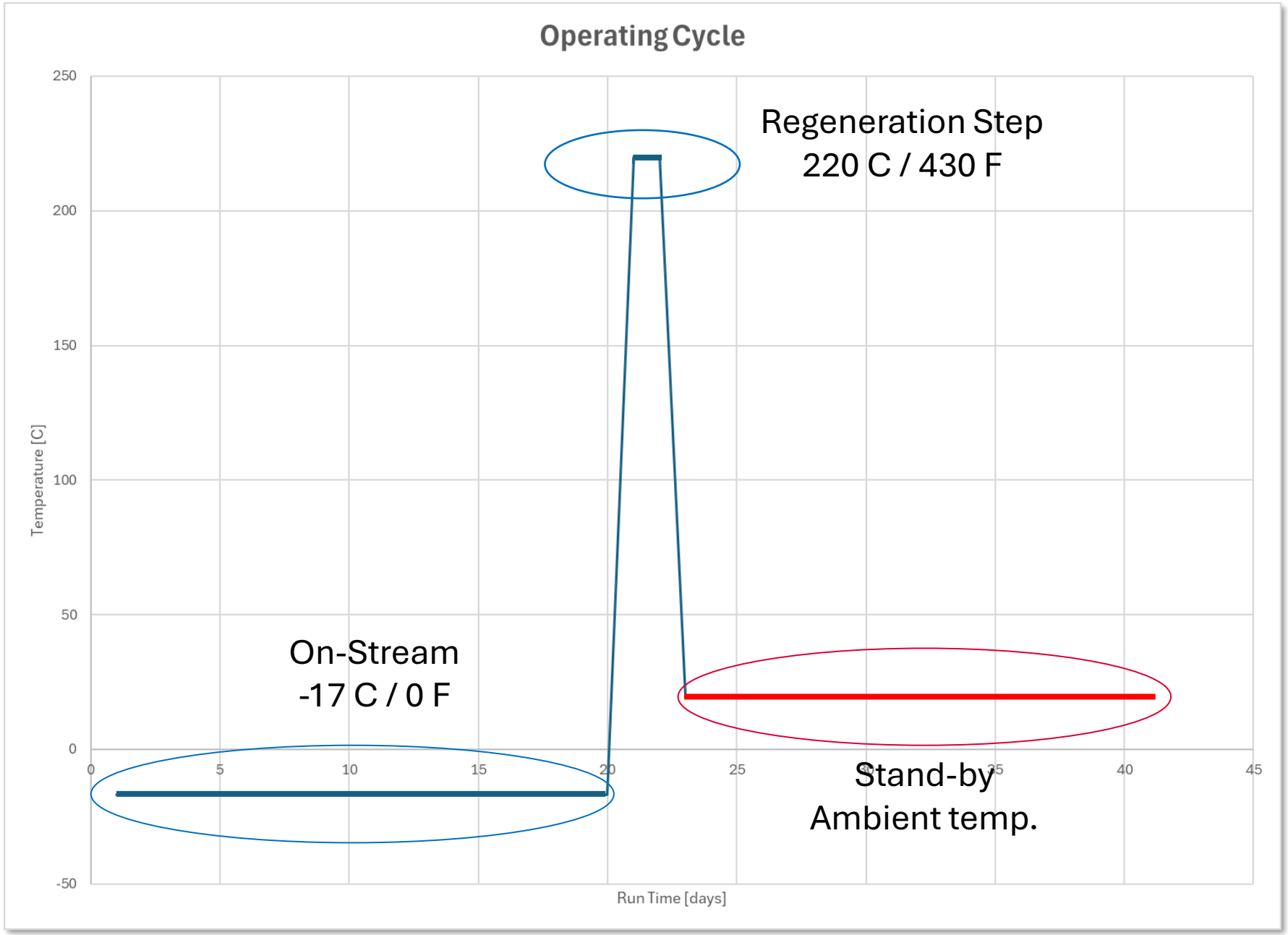

Outside CUI Range

Inside CUI Range

The piping inspection frequency is based on the hazard rating

Appendix A – Table 1 Piping Inspection Class based on Hazard / Risk Potential

Threshold Quantity or Release Potential ►► / Hazard / Risk Category▼ ▼	100 – 1000 Lbs	1000 - 10,000 Lbs	10,000 - 100,000 Lbs	100,000 + Lbs
Very Toxic ≥ Boiling Point	Class 2	Class 1	Class 1	Class 1
Very Toxics < Boiling Point Extremely; Flammable Extremely Explosive; Toxics ≥; Boiling Point	N/A	Class 2	Class 1	Class 1
Toxics < Boiling Point; Explosives; Oxidizers; Highly Flammable Liquids w/ Boiling Point < 95ºF / 35ºC; Water reactive - liberates toxic gas; Violently reacts w/ Water; Very Toxic to Aquatic Organisms		N/A	Class 2	Class 2
Highly Flammable Liquids with Boiling Point > 95º 35ºC; Flammable Liquids; Toxic to Aquatic Orga and may cause long term adverse effects in the environment	N/A	N/A	N/A	Class 3

Step 1
Determine Inspection Class

Step 2
Select Inspection Frequency

A. Class 1 Piping	Maximum* Visual Inspection Interval	5 years
	Maximum Non-Destructive Testing Interval	5 years
B. Class 2 Piping	Maximum* Visual Inspection Interval	5 years
	Maximum Non-Destructive Testing Interval	10 years
C. Class 3 Piping	Maximum* Visual Inspection Interval	10 years
	Maximum Non-Destructive Testing Interval	10 years