OVERVIEW

• General causes of CUI

• Suspect Areas- how to find and where to start

• Inspection Methods and Techniques for preventing failures due to CUI

• Pro’s and Con’s on Inspection Techniques
Corrosion Under Insulation (CUI):
- External corrosion of carbon steel piping, pressure vessels and structural components resulting from water trapped under insulation in conjunction with other variables that accelerate and drive the corrosion
- External chloride stress corrosion cracking of austenitic and duplex stainless steel under insulation, again with other variables present that accelerate the corrosion

CUI is a phenomenon that has plagued the Oil, Gas and Chemical Industry for years.
Billions of dollars spent worldwide due to CUI

- Unscheduled downtime caused by failures of CUI
- Scheduled downtime for inspections and repairs
- Routine in-service inspection programs
- Preventive measures taken to mitigate and prevent CUI
- Cost of new materials
Root Causes of CUI

- Presence of aerated water in the Insulation System
  - Overall condition of Insulation system
    - Punctures, slipped jackets, seal deterioration, water retention

- Temperature of steel and surrounding atmosphere
  - Operating within CUI temp ranges, intermitting service
    - CS - 25F - 300F  SS - 120F – 300F

- Corrosive contaminants species found in the Water
  - rainwater, acid rainwater in industrial regions, salt water, fire system deluge water and contaminants from the surface of steel
Overall GOALs in the Fight against CUI

✓ Safety and Protection to the Employees and Public

✓ Respect and Preserve the Environment we live in

✓ Reduce/Eliminate costly repairs and unexpected failures to increase Reliability
Getting started on the fight against CUI

➢ **Have a strategic PLAN of ATTACK**
  • Prioritize inspections on Piping and Equipment
    • Potential risk of failure, process, cost

➢ **Identify material and location of Piping/Equip**
  • Carbon or Stainless materials, Temp.
    • Located near cooling tower, coastline, standing water

➢ **Data collection and Management**
  • Analyze inspection history to better future inspections
Inspection Methods and Techniques

- Visual Inspection

- Radiographic Examination Methods (several)
  - Real-Time (fluoroscopy), Profile RT, Digital RT

- Guided Wave Examination (GWT)

- Neutron Backscatter
Visual Inspection (VT)

- VT of Piping / Equip can serve as a “baseline” to help establish a plan of action and path forward

- Two basic types of VT examinations
  - VT with Complete Removal of Insulation
  - VT with Partial Removal of Insulation

- Utilizing ISO’s/P&ID’s or Equip drawings for documentation
  - Suspect Area’s, Temperatures Readings, Locations

- Create or use a VT inspection checklist
  - List common factors to look for (punctures, slipped jackets, etc)
**Visual Inspection (VT)**

**Key areas for Suspect Locations**

- Damaged areas of insulation
- Protrusions of Punctures
- Insulation Termination Pts.
- Damaged Seals
- Poor Installation of Insulation
- Weather Proofing/Mastic Wraps
VT with Complete Removal of Insulation

**Advantages**
- Method ensures 100% of all OD surface area is examined
- Eliminates any misinterpretation from more technical NDE

**Disadvantages**
- Expensive – remove and reinstallation of insulation
- May require additional funds and time for scaffolds
- Asbestos
- Process Problems
VT with Partial Removal of Insulation

**Advantages**

- Cost associated with complete removal can be significantly reduced
- May not experience Process Problems

**Disadvantages**

- Limits Inspection / Reduces Confidence
- Creates potential areas for water ingress
- Have to verify that all insulation repairs are re-installed properly
Consideration on Partial Removal of Insulation

- Placement of Windows should be thought out
  - Cut where CUI is most likely to occur

- May need to cut several windows

- Vertical strips may need to be cut due to Temp Zones

- Remove a Representative amount due to Condition of Pipe/Equip
VT Inspection at inspection ports can be Misleading

Locations where insulation plugs have been removed to permit thickness measurements on insulated piping should receive particular attentions
Pipe Supports – Common Suspect Areas for CUI
Visual Inspection (VT)

CUI can be hard to find- Identifying Where to Start is Key

- Areas exposed to mist overspray from cooling water towers.

- Areas exposed to steam vents.

- Carbon steel piping systems insulated for personnel protection operating between 25° F and 300° F

- Carbon steel piping systems that normally operate in-service above 250° F but are intermittent service.

- Dead legs and attachments that protrude from insulated piping and operate at a temperature different than the active line.

- Piping systems with deteriorated coatings and/or wrappings
Neutron Backscatter

- Effective tool to scan hundreds of feet of insulated pipe to determine wet/saturated insulation in a short amount of time
- Can help pin-point suspect areas for potential CUI
Neutron Backscatter Method

• Radioactive source emits high energy (fast) neutrons into desired location of insulation

• High energy neutrons travels through the insulation and collide with light elements (hydrogen) transforming into low energy neutrons

• A sensitive detector partial to low energy neutrons is used to identify the “Wet Insulation” by measuring the count of low energy neutrons: the count is proportional to the amount of water in the insulation
Neutron Backscatter Method

- Relatively quick and accurate method for identifying suspect areas for the potential of CUI
- Can access elevated areas without the need of scaffolding
- Lightweight and versatile to reach congested areas
- Only a screening tool to identify wet/saturated insulation, cannot detect or measure corrosion
Radiographic Inspection Methods

- Radiographic Examination is a very effective method that can be used for the Inspection of CUI
Radiographic Inspection Methods

- **Meat and Potatoes of Inspection for CUI**

  ✓ Unlike other methods Radiography cannot only find CUI but also produce accurate wall lose measurements **without** insulation removal

  ✓ Can be utilized while Pipe/Equip is In-Service
Radiographic Inspection Methods

- There are many types of Radiography techniques
  - Real-Time Radiography (RTR)
  - Computed Radiography (CR)
  - Digital Detector Array (DDA)
Real-Time Radiography RTR

- Non-destructive testing method that produces an image electronically rather than on film creating little lag time for the resulting image

- Standard X-ray system is used in addition with an image intensifier to examine components in real time, resulting in better inspection coverage at higher inspection speeds

- Portable X-ray tube and imaging device provides 3-D perspective and an increased resolution or field of view as the operator moves closer or farther away from the test subject

- Data can be stored by video image or still images
Real-Time Radiography RTR

- RTR has a low radiation source that penetrates the insulation and produces a silhouette of the pipes OD

- Inspector can use the real time display and verify CUI- marking areas for further inspection

- Capable of scanning 100% of the piping system (if accessible) while In-Service by rotating device 360 degrees

- Low source of radiation allows for safe operation without disrupting surrounding work
Real-Time Radiography RTR

Limitations

- Only a screening tool, can’t generate accurate wall loss measurements
- Requires adequate clearance to scan 100% of desired area
- Wet insulation can lessen visibility
Profile Radiography

- Great tool for Inspection at Suspect Areas of CUI

- Not only a Screening Tool but can also Produce Accurate Measurements of Wall Loss

- Used in Conjunction with RTR method will result in High Confidence Levels of Inspection

- Can take Profile at multiple different angles to catch Area of Interest
Profile Radiography

Computed Radiography CR

- CR uses a PSP (photo stimulable phosphor) Plate instead of Conventional Film

- PSP Plate is loaded into a laser scanner and translated into digital image
  - No chemicals or darkroom needed

- Produces a sharper image than conventional film in less time
  - 1-5 minutes vs. 10-20 minutes

- Images can easily be stored and electronically distributed to others
Digital Detector Array (DDA)

- DDA digitizes the photon radiation directly into an image which can be displayed on a computer monitor
  - Can be stored and distributed electronically

- Produces Superior Quality to other RT forms in a shorter time
  - Can produce an image within seconds

- Less radiation needed to produce image compared to Film RT

- Requires a computer monitor and cables for immediate viewing of Image
Radiographic Inspection Methods

- Overall Radiography is a very effective means of inspecting for CUI, eliminating the need to remove insulation SAVES time and money.
Guided Wave Inspection

• Effective Ultrasonic SCREENING tool to detect general corrosion and wall loss

• Able to scan long sections of pipe - helps locate areas needing a more detailed inspection to assure reliability of pipe/equip
Guided Wave Inspection

• Only requires a few feet of insulation to be removed for application

• Can scan approx 100-150’ of pipe in each direction of collar (can be Limited)

• Will identify suspect areas of corrosion in a short period of time, which can then be proved up with other conventional NDE

• Detects not only external corrosion but also internal

• Can inspect In-Service lines
Guided Wave Inspection

• **Multiple applications**
  
  - Coated / Insulated Pipe
  - Above-ground or buried piping
  - Overhead piping
  - Road Crossings
  - Wall Penetrations
Guided Wave Inspection
Guided Wave Inspection

**Limitations**

- Can not measure exact percent of corrosion, only a screening tool to locate and give an estimated percent of wall loss

- Only effective for temps $< 250$ F

- Confidence and Sensitivity decrease with length
  - Signal will terminate at a flange or at second elbow
  - Signal also weaken with increased number of welds or branches

- May not detect defects in immediate vicinity of welds

- Operator Dependent
Summary

• Have a Plan for CUI Inspections
  • If you Fail to Plan you Plan to Fail

• Choose Inspection Methods Accordingly

• Be PROACTIVE
  • Don’t wait for a CUI failure to spark your inspections, IT MAY BE TO LATE!!