Inspector Training on Corrosion Under Insulation

NRC Weekly Knowledge Management

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Overview

- Background
  - Contributors and effects
  - Operating experience
- How to Spot Corrosion Under Insulation
  - Limitations
  - Inspector best practices
- Scoping in Licensee Programs
  - Applicable NRC requirements
  - Standards for renewed operating licenses
  - Plant procedures

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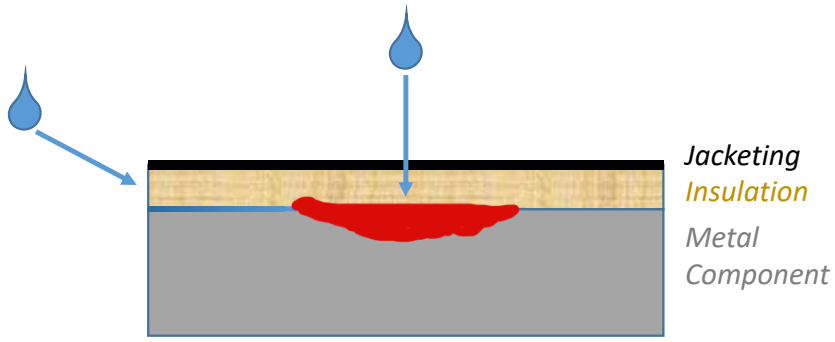
Background

What is corrosion under insulation?

- The external corrosion of a metal component where the corrosion is either masked and/or exacerbated by the insulation.

- Most issues have been observed to occur on uncoated carbon steel.



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Background – Cause

Cause: Moisture intrusion and contact with the exterior surface of the component over time.

Contributors	Effects

• Coated vs uncoated
• Insulation configuration
• Insulation material
• Environmental conditions
  ○ Indoor versus Outdoor
  ○ Marine environment
  ○ Operating temperature
	• General corrosion
	• Pitting corrosion
	• Through-wall leak
	• Rupture

Background – Operating Experience

- **Diablo Canyon Unit 2** (2020, ML20303A238) – Through-wall leak on auxiliary feedwater system piping elbow.
- **Salem Unit 1** (2017, ML18039A899) – Degraded containment liner.
- **Clinton** (2016, ML16130A710) – Degraded structural support for control room ventilation.
- **South Texas Project Unit 2** (2010, OE30955) – Through-wall leak on non-safety closed cooling water piping.
- **Waterford Unit 3** (2009, OE28818) – Pitting on condensate make-up water piping to wet cooling tower.

Background – Operating Experience

Diablo Canyon Unit 2

Salem Unit 1

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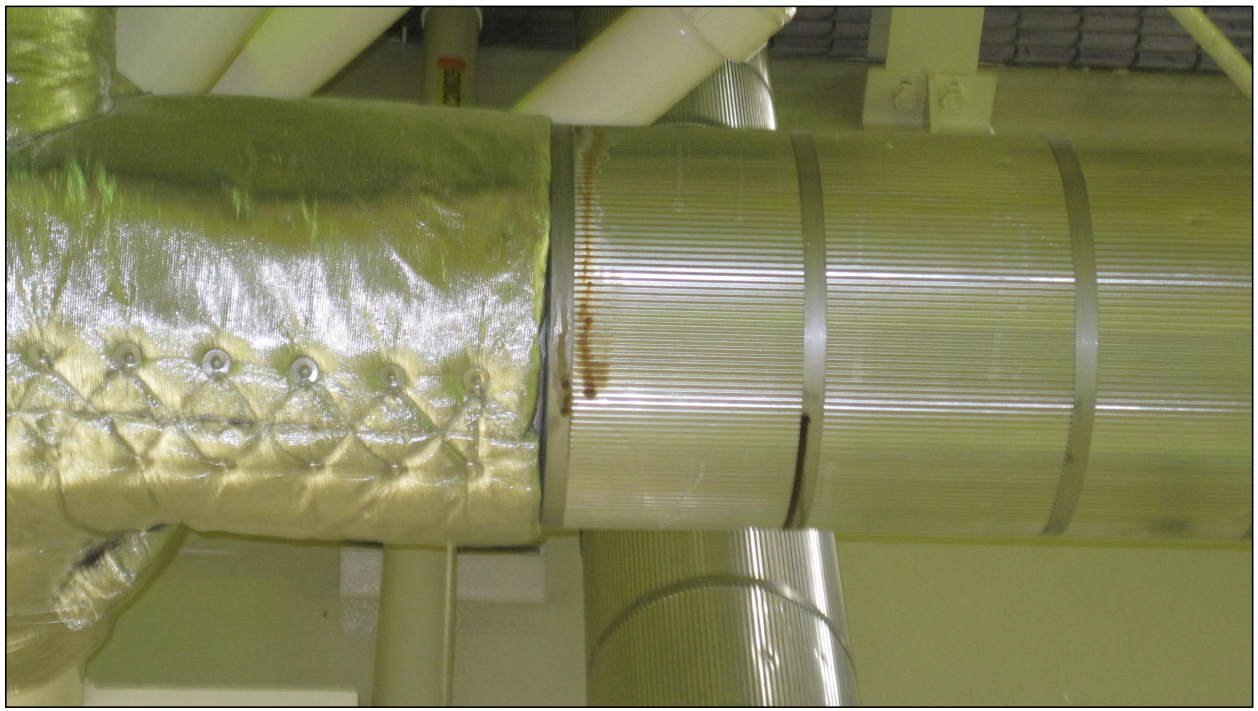
How to Spot Corrosion Under Insulation

Quiz: Can you tell the condition of the component underneath?



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How to Spot Corrosion Under Insulation

Limitations

- In most cases, you CANNOT conclude there is corrosion under insulation until a through-wall leak develops.

- However, there are some indirect visual indications that you may use:
  - Debris and deposits
  - Discoloration and staining
  - Displacement

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How to Spot Corrosion Under Insulation

Damaged and Displaced

Staining

Caution

These are indirect visual indications only. The insulation must be removed to confirm. The requirements for removal vary.

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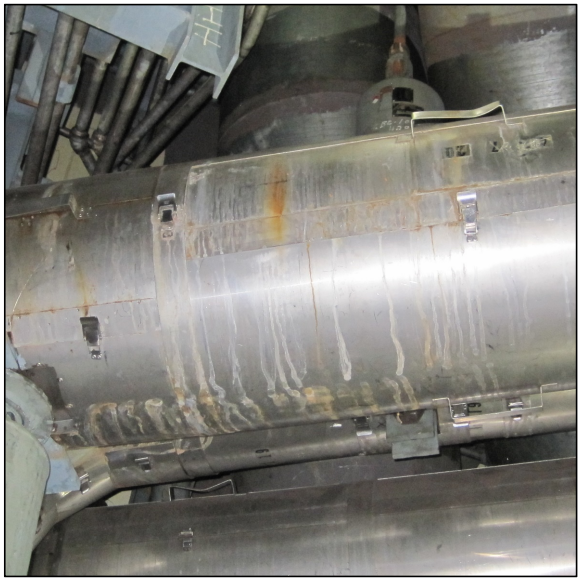
How to Spot Corrosion Under Insulation



Staining

Deposits

Deposits and Discoloration

Caution

These are indirect visual indications only. The insulation must be removed to confirm. The requirements for removal vary.

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How to Spot Corrosion Under Insulation

This is one component from the previous slide.

Conclusion:
The licensee discovered corrosion and a small, through-wall leak after the insulation was removed.

Leakage was evident from the seam of the insulation and on the floor below.

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How to Spot Corrosion Under Insulation

Inspector Best Practices

- Check for debris on and around the component. This could be corrosion products or displaced insulation.
- Check the surrounding area for evidence of leakage, including the floor, equipment surfaces, and other areas where leakage may be channeled. This could be in the form of deposits or staining.
- Check for longstanding moisture from above that may cause a wetting and re-wetting cycle of the insulation surrounding uncoated piping.
- Check for loose fitting insulation (visual, non-intrusive check only).

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How to Spot Corrosion Under Insulation

Inspector Best Practices Cont'd

- Consider the operating environment and insulation configuration. For example:
  - Water source (condensation, rain, etc.) and open pathway.
  - Corrosion on the adjacent, non-insulated portion of the component.
- Consider digging into the design and licensing basis for the plant with respect to what piping systems are insulated and why.
- Keep your eyes open for opportunity underneath (perhaps sections of insulation removed to support maintenance activities or plant mods)

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Scoping in Licensee Programs

Applicable NRC Requirements

- 10 CFR 50
- ASME BPV Section XI

  IWA-5000, System Pressure Tests
  - *Class 1* – No hold time.
  - *Class 2/3* – No hold time required if the system has been in operation for:
    - > 4 hours (insulated components)
    - > 10 min (non-insulated components)
  - When examining insulated components, the examination of the surrounding area for evidence of leakage shall be required.
  - For borated systems, insulation shall be removed from pressure retaining bolted connections for VT-2* visual examination.

**VT-2: Detect evidence of leakage*

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Scoping in Licensee Programs

Standards for Renewed Operating Licenses

- Generic Aging Lessons Learned (GALL) Report
  - LR-ISG-2012-02, "Interim Staff Guidance – Aging management of Internal Surfaces, Fire Water Systems, Atmospheric Storage Tanks, and Corrosion Under Insulation."
  - GALL Report AMPs XI.M29 and XI.M36 were revised to recommend periodic inspections during each 10-year period of the period of extended operation.
- Aging Management Programs
  - AMP XI.M29, "Aboveground Metallic Tanks"
  - AMP XI.M36, "External Surfaces Monitoring of Mechanical Components"
- NRC Safety Evaluation Report
  - There may be plant-specific commitments to remove and inspect under insulation.
  - Verify what the NRC required at the time of license renewal, especially for those plants before 2012.

Scoping in Licensee Programs

Plant Procedures

- Corrective action program and operability determination processes.
- Visual examination of piping to meet ASME Code requirements.
- Implementation of license renewal commitments and aging management programs (*as applicable*).
- Self-imposed examinations from operating experience.

Reference Slides

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OpE

Operating Experience

- Diablo Canyon Unit 2 (2020, ML20303A238) – Through-wall leak on auxiliary feedwater system piping elbow
  - Issue: Licensee failed to appropriately screen relevant operating experience, received in 2009 and 2010, relating to corrosion of carbon steel piping under insulation.
  - Cause: Located in an outside environment susceptible to the general conditions of the maritime location.
  - CA: Permanently removed piping insulation from the affected piping.

OpE

Operating Experience

- Salem Unit 1 (2017, ML18039A899) – Degraded containment liner
  - Issue: Licensee failed to identify and correct a non-conformance with the Unit 1 containment thermal insulation system.
  - Cause: Configuration did not provide a watertight seal between the containment liner and the insulation cover, and as a result, periodic service water leakage seeped behind the insulation and caused corrosion of the containment liner.
  - CA: Modified top of the insulation panels to prevent water intrusion.

OpE

Operating Experience

- Clinton (2016, ML16130A710) – Degraded structural support for control room ventilation
  - Issue: Licensee failed to identify that a structural support associated with control room ventilation ‘B’ was degraded to the point it no longer conformed to the seismic analysis.
  - Cause: Condensation and configuration of insulation allowed moisture contact and corrosion of the supports.
  - CA: Re-apply a coating to the supports as well as research and install insulation that was more breathable to minimize moisture accumulation and preclude any further degradation.

OpE

Operating Experience

- South Texas Project Unit 2 (2010, OE30955) – Through-wall leak on non-safety closed cooling water piping.
  - Issue: Three gallon per hour through-wall leak was discovered during normal plant operation on outdoor cooling water piping for feedwater booster pumps.
  - Cause: Degradation of aluminum jacketing allowed rainwater to enter the calcium silicate insulation (insulated for freeze protection). Construction specifications did not require coating insulated piping.
  - CA: All the piping was coated before insulation is reapplied. Isolation valves are being added to minimize the amount of common piping.

OpE

Operating Experience

- Waterford Unit 3 (2009, OE28818) – Pitting on condensate make-up water piping to wet cooling tower.
  - Issue: Discovered during routine inspection and painting of piping under insulation. Waterford Unit 3's external corrosion program systematically performs routine inspections and painting of piping under insulation.
  - CA: Expanded inspection scope under current plant program.