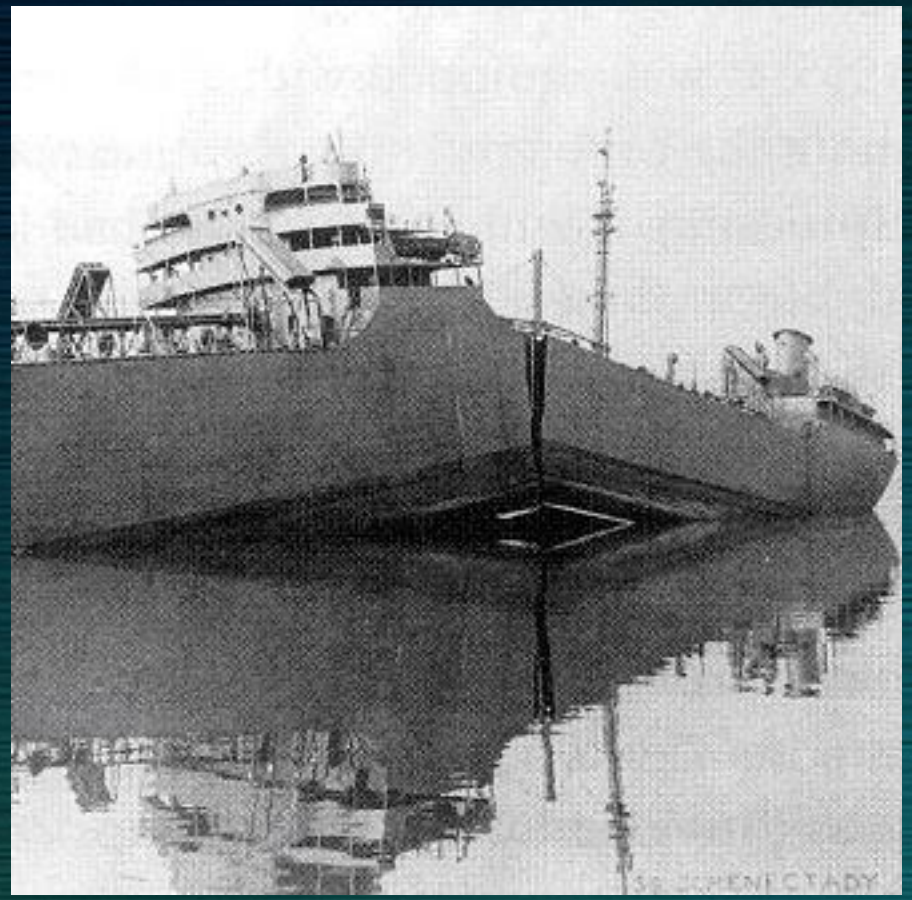
Mechanical Integrity Inspections of Pressure Vessels, Piping, and Storage Tanks:

The Importance of Reliability Inspection Programs to Maintain Safety, Uptime, and Asset Value of Plant Equipment



WRBA Conference – March 2017

EVERGREEN ENGINEERING, INC.
Engineering and Construction Services

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Evergreen Engineering, Inc.

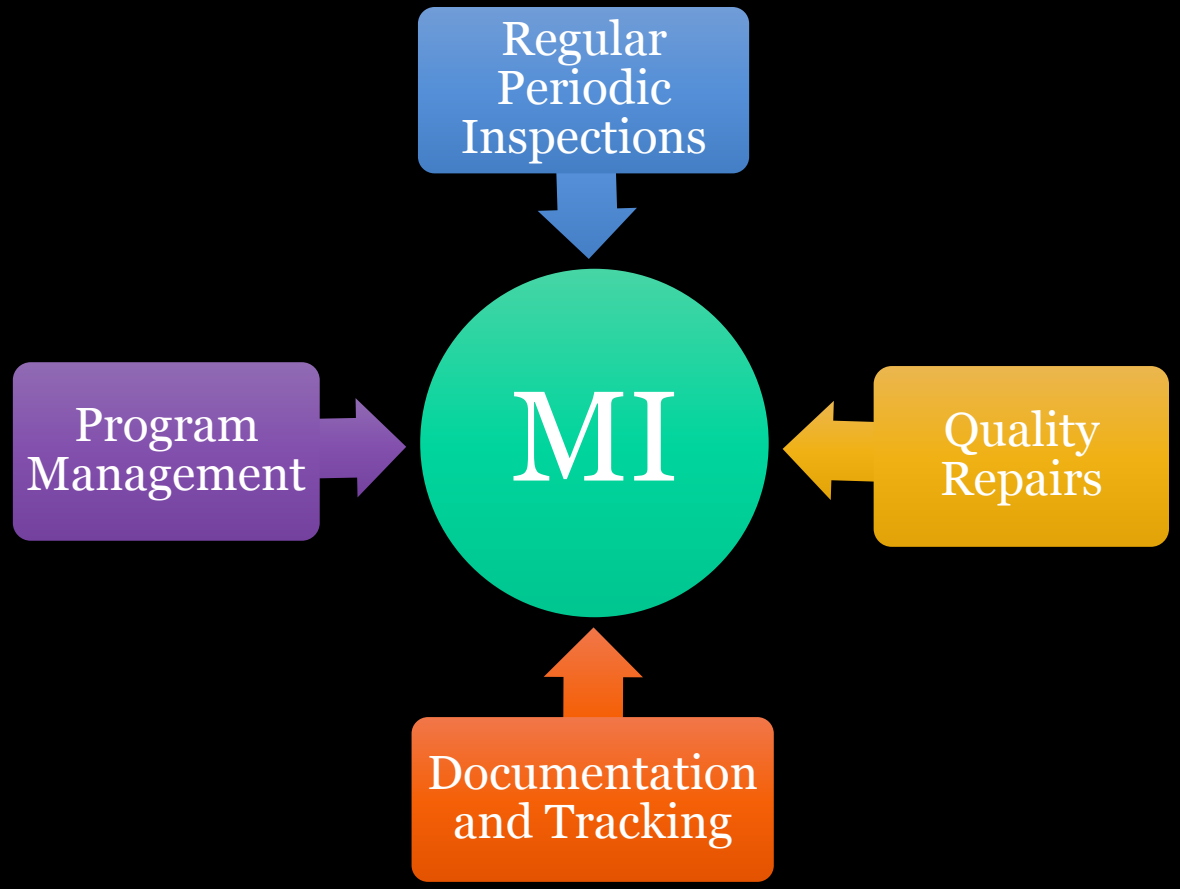
- >15 years of operational and management expertise in power plants (nuclear, wood-fired, natural gas power & package, chemical recovery).
- Specializing in boiler plant maintenance outage planning and execution: project management and work scope development, contractor management, managing boiler repairs, preventative maintenance programs, and non-destructive testing activities.

Regular periodic inspections of pressure vessels, piping, and tanks help maintain their safety, reliability, and value, and reduces the risk of equipment failure and unplanned plant downtime. The presentation will discuss:

- Types of compliance and reliability inspections of equipment such as fired/unfired pressure vessels, process piping, and aboveground storage tanks
- Applicable guiding codes and standards such as API, ASME, BPVC, and NACE
- Typical inspection techniques and inspector qualifications
- The role of project management in an effective Mechanical Integrity program

What is Mechanical Integrity (MI)?

- A living program of inspection, repair, documentation, and management
- Ensures equipment critical to the safety or operation of the process remains functioning as was originally designed
- Part of an effective Process Safety Management program



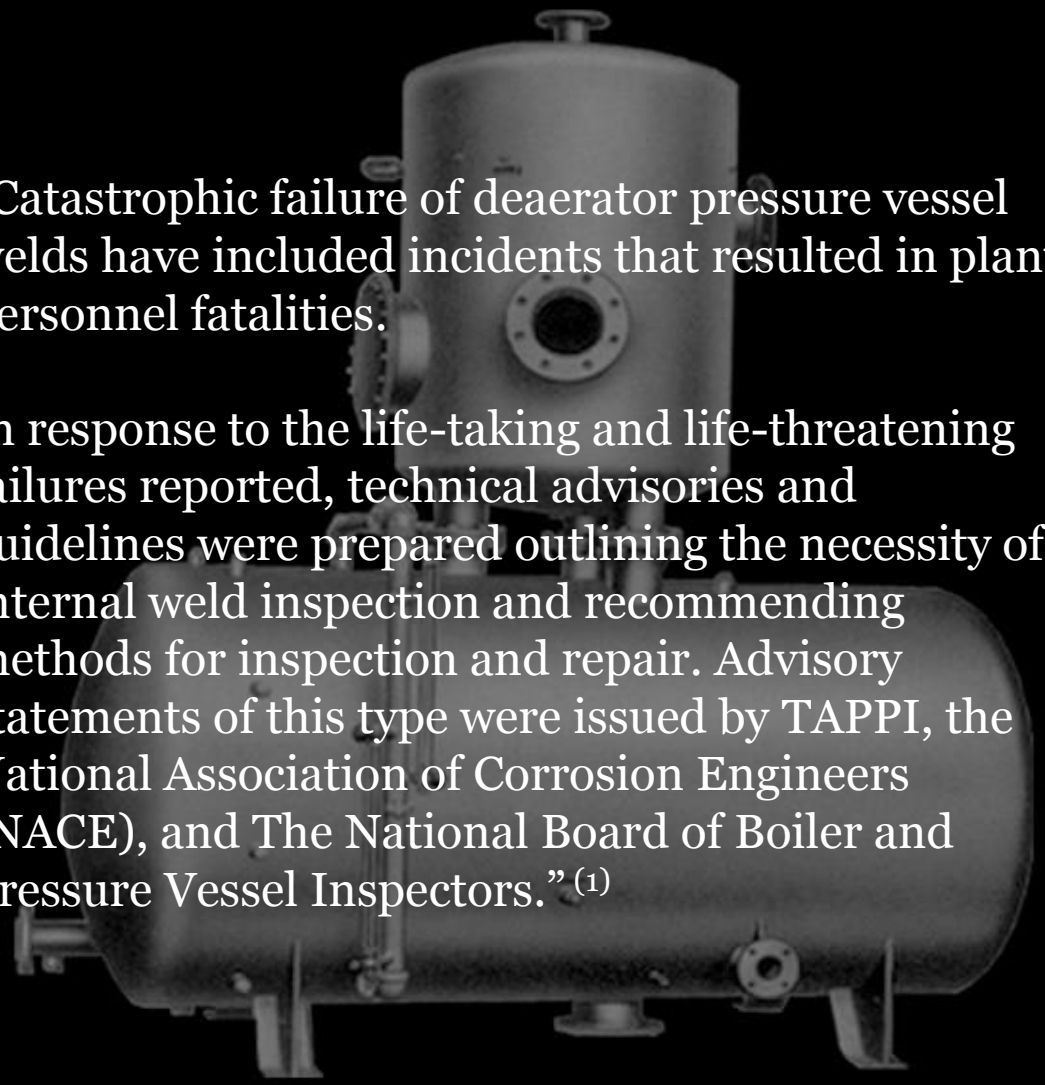
MI Program:

Basic Elements

1. Identify critical equipment.
   - Location, specifications, nameplate/manufacturer's data
   - Ensure equipment is designed, fabricated, installed, and operated per its intended purpose.
2. Identify guiding code or standard.
3. Determine frequency and type of inspection required.
4. Perform inspections & repairs using qualified resources.
5. Document findings, and retain records.
6. Audit/quality check program data.
   - Lessons learned, equipment changes

Common Critical Equipment:

- DA Tanks
- Blowdown Piping
- Condensate Tanks
- Atmospheric Flash Tanks
- Aboveground Storage Tanks
- Digesters
- Process Piping
- Feedwater Check Valves



"Catastrophic failure of deaerator pressure vessel welds have included incidents that resulted in plant personnel fatalities.

In response to the life-taking and life-threatening failures reported, technical advisories and guidelines were prepared outlining the necessity of internal weld inspection and recommending methods for inspection and repair. Advisory statements of this type were issued by TAPPI, the National Association of Corrosion Engineers (NACE), and The National Board of Boiler and Pressure Vessel Inspectors." (1)

DA TANKS

1. Guiding Codes / Standards
2. Frequency, Inspection Type, & Inspector Qualifications
3. Typical Inspection & Repair

(1) National Board of Boiler and Pressure Vessel Inspectors, *National Board BULLETIN*, April 1988

DA TANKS

1. Codes/Standards That May Apply:

- API 510

  "Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair, and Alteration"

- API RP 572

  "Inspection of Pressure Vessels" Recommended Practice (<15psi)

- NACE RP0590

  "Standard Recommended Practice for Prevention, Detection, and Correction of Deaerator Cracking"

- ASME BPVC Section V

  "Nondestructive Examination"

- ASME BPVC Section VIII

  "Rules for Construction of Pressure Vessels (Division 1)"

  - >15psi

DA TANKS

2. Frequency, Inspection Methods, & Inspector Qualifications:

- Newly placed into service:
  - Within the first 2 years
- No recent cracks or repairs:
  - Category 1 classification: "No relevant discontinuities detected"
  - Every 3 – 5 years
- Non-repaired crack:
  - Category 2 classification: "Discontinuities were detected but weld repairs not required"
  - Recheck annually
- Crack repairs:
  - Category 3 classification: "Discontinuities were detected and weld repairs required"
  - Recheck repairs within 1 year
  - Vessels w/ history of cracks should be inspected every 3 years or less

DA TANKS

2. Frequency, Inspection Methods, & Inspector Qualifications:

- Visual inspection to assess general condition of the internal welds and internal surfaces corresponding to external attachment welds.
- Wet Fluorescent Magnetic Particle (WFMT) inspection of 100% of the welds.
  - Nozzle, head-to-shell, longitudinal, circumferential and plug welds; and internal surfaces corresponding to external attachment welds.
  - WFMT is preferred method, but PT, RT, and UT may be used as supplemental techniques to expand the inspection.
  - Proper surface preparation (light grinding) prior to inspection is very important

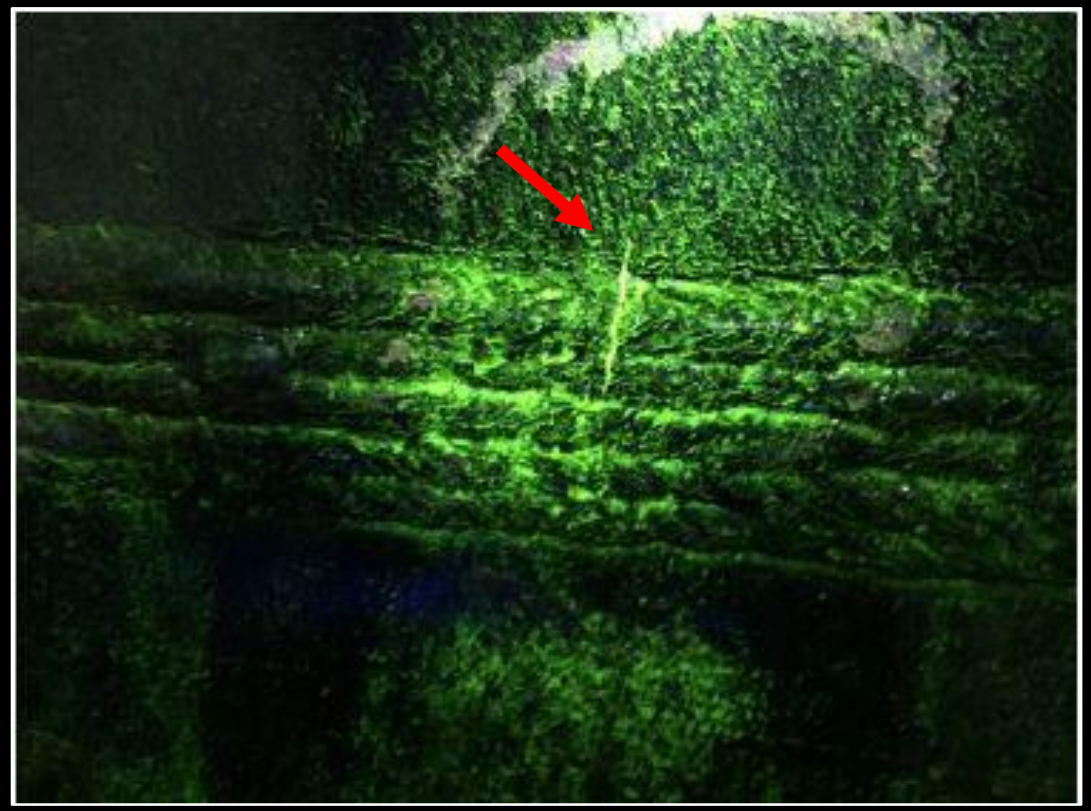
DA TANKS

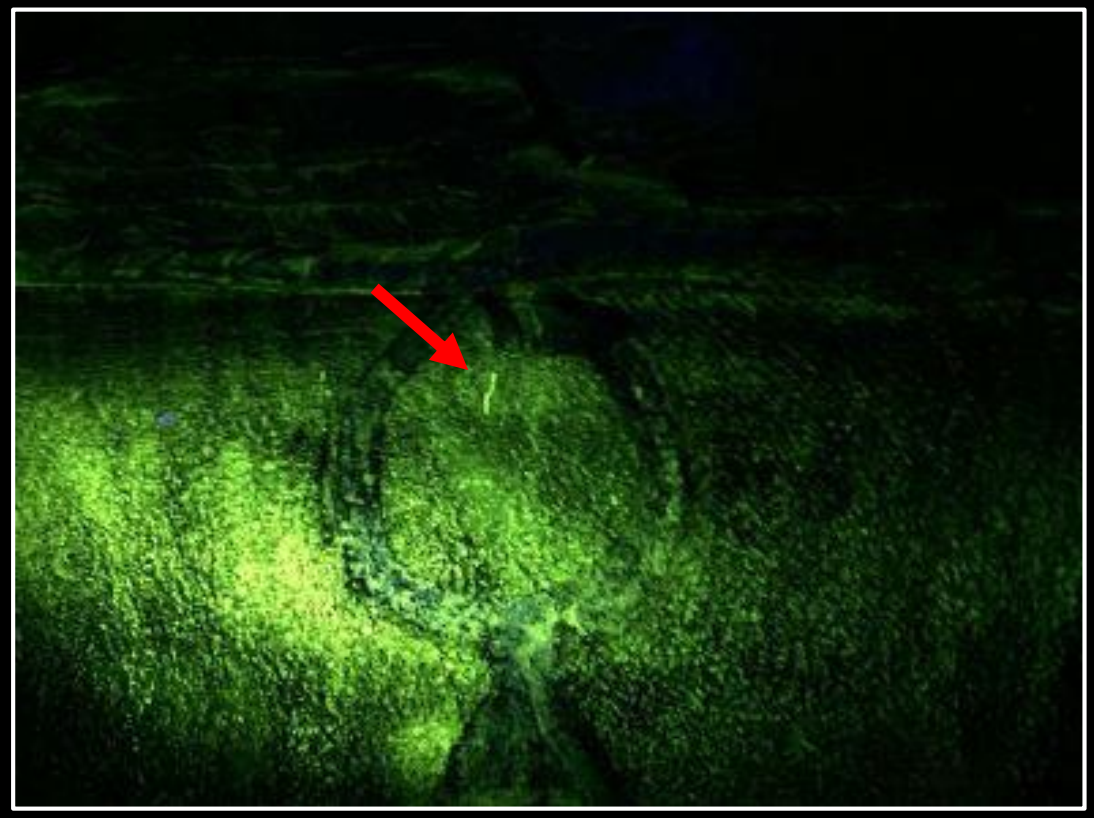
2. Frequency, Inspection Methods, & Inspector Qualifications:

- Inspection personnel must be trained and certified in accordance with ASNT SNT-TC-1A or equivalent to a minimum of Level I.
- Interpretation of results to be made by Level II certified personnel.
  - Most NDE/NDT companies have technicians certified to appropriate level/method.
- Having an inspector that is also a qualified CWI is valuable to assist with repair recommendations and repair QA.
- Repair organization should use welders and procedures qualified in accordance with applicable code.

DA TANKS

3. Typical Inspection & Repair:





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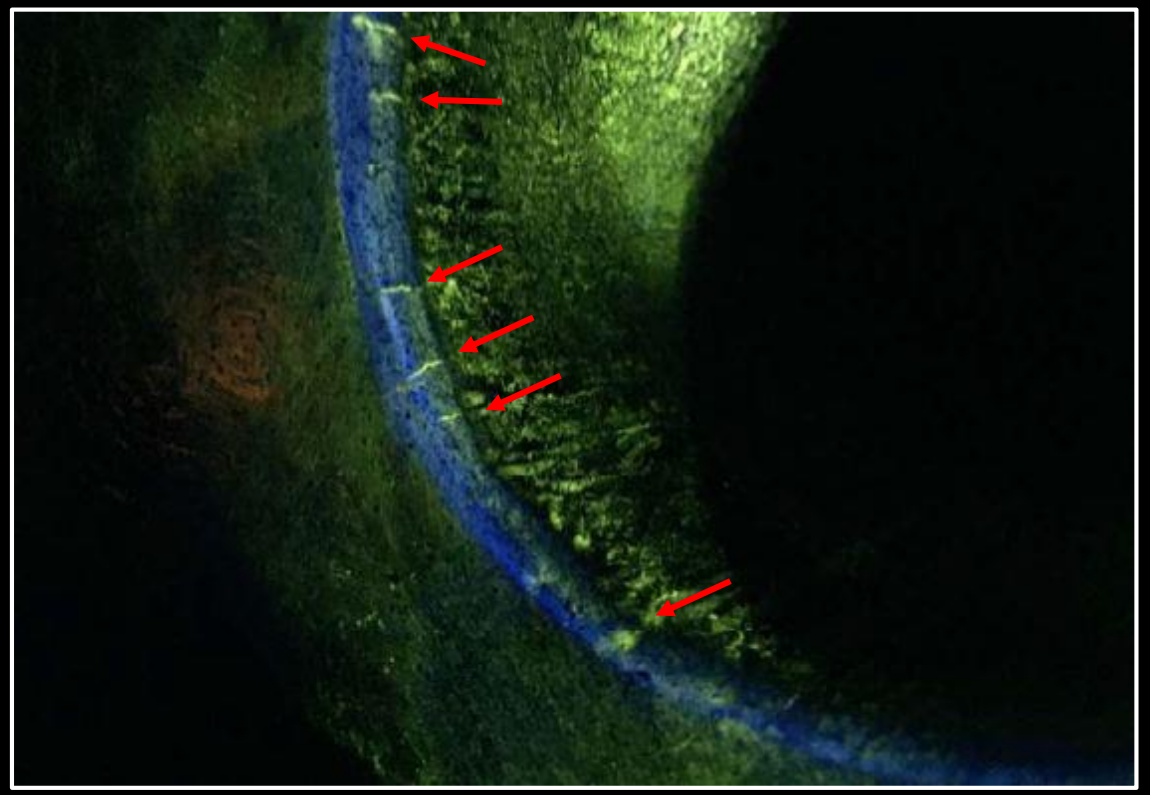

BLOWDOWN PIPING

1. Guiding Codes / Standards
2. Frequency, Inspection Type, & Inspector Qualifications
3. Typical Inspection & Repair

BLOWDOWN PIPING

1. Codes/Standards That May Apply:

   - ASME BPVC Section V

     "Nondestructive Examination"

   - ASME B31.3

     "Process Piping" Code for Pressure piping (acceptance criteria)

   - API 570

     "Piping Inspection Code"

     - Steam/condensate piping covered at owner/user's option

BLOWDOWN PIPING

2. Frequency, Inspection Methods, & Inspector Qualifications:

- Generally falls under the category of risk-based inspection (RBI).
  - The frequency and extent of inspection depends on the type of degradation and consequence of a piping failure.
- A good guideline is to inspect all blowdown piping every 5 years.
  - Depending on condition and service, piping may need more frequent inspection.
- An RBI assessment can be used to increase or decrease inspection frequency.

BLOWDOWN PIPING

2. Frequency, Inspection Methods, & Inspector Qualifications:

- Visual inspection – external:
  - Determine the condition of the outside of the piping, insulation system, painting and coating systems, and associated hardware.
  - Check for signs of misalignment, vibration, and leakage.
  - Survey the condition of piping hangers and supports.
  - Look for any field modifications or temporary repairs, or parts that may be unsuitable for long-term operation (improper flanges, temporary patches, flexible hoses, valves of improper specs, etc.).
  - Can usually be performed while piping is in service.

BLOWDOWN PIPING

2. Frequency, Inspection Methods, & Inspector Qualifications:

- Thickness inspection:
  - Determine the internal condition and remaining thickness of the piping.
  - Establish thickness measurement locations (TMLs) at specific areas along the piping circuit.
  - Most accurate method of thickness measurement is UT, but RT can also be used.
  - Typically the system should be offline during the inspection (above 150F -> safety concern and requires different couplant and instruments)
- Areas of concern:
  - Injection points
  - Dead legs
  - Corrosion under insulation
  - Erosion / corrosion / flow accelerated corrosion (FAC) at areas of turbulent flow, such as at changes of direction in the piping or downstream of control valves

BLOWDOWN PIPING

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BLOWDOWN PIPING

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Thank You!