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# Oyster Creek / Exelon Buried Piping Experience

October 22, 2009

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## Oyster Creek / Exelon

✓ Agenda
- Overview
- Oyster Creek Underground Piping Leaks
- Buried Piping Program
- Exelon Experience & Plan
- Technical Discussion of Lessons Learned for Buried Piping Experience

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## Overview

- ✓ Exelon has changed approach—more proactive
- ✓ Exelon is inspecting buried piping at all sites with a formal program consistent with industry approach
- ✓ Long term repair/replacement projects being identified to improve the reliability of high risk piping
- ✓ No public health or safety consequences
- ✓ Affected public perception / confidence

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## April 2009 Tritium Leak

- ✓ Leaks in the 8-inch and 10-inch carbon steel Condensate Transfer System lines
- ✓ 8-inch line understood to be Stainless Steel
- ✓ 10-inch line under vacuum during power operation
- ✓ No plant operational or nuclear safety issues associated with the leaks

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## April 2009 Tritium Leak

✓ Causes

- Root Cause 1: "anodic dissolution" in conjunction with a susceptible material
- Root Cause 2: erroneous assumptions in program basis led to flawed tritium mitigation strategy
- Contributing Cause 1: improperly applied coatings during repairs in the early 1990s
- Contributing Cause 2: change management processes were inadequate
- Contributing Cause 3: 100% verification of piping integrity is not practical

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## April 2009 Tritium Leak

✓ Corrective actions to prevent recurrence

- Move affected direct buried piping either above ground or in monitored trenches
- Perform a thorough program assessment and update the program based on the results

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## August 2009 Tritium Leak

- ✓ Six-inch aluminum Condensate Transfer line
- ✓ Piping leak occurred inside the Turbine Building wall penetration
- ✓ Identified through Turbine Building sump pump-down rate
- ✓ No plant operational or nuclear safety issues associated with the leak

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## August 2009 Tritium Leak

- ✓ Causes
  - Root Cause 1: galvanic corrosion resulting from a coating breach
  - Contributing Cause 1: incomplete extent of condition reviews
  - Contributing Cause 2: buried piping program does not include piping internal to penetrations and the conditions of the penetrations are typically unknown

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## August 2009 Tritium Leak

✓ Corrective actions to prevent recurrence
- Implement a risk-based strategic inspection plan including all piping traversing though piping penetrations

✓ Additional corrective actions
- Institutionalize guidance to document as-left conditions following excavations
- Inspect all piping penetrations and document the as-found and as-left conditions

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## Buried Piping Program

✓ **Goal:** Ensure structural integrity, prevent forced outages, avoid emergent repairs, eliminate environmental impact and enable sites to implement well planned repairs in a timely manner.

✓ Process is 4 steps
1. Pre-Assessment Analysis
2. Indirect Assessment
3. Direct Examination
4. Post Assessment

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## Exelon Buried Piping Program Approach

- ✓ The original approach for the Exelon Buried Piping Program was to categorize the high risk piping, perform inspections, and repair/replace based on unacceptable inspection results and/or actual leakage.
- ✓ The approach has changed to add a proactive replacement or containment strategy to the Buried Piping Program as a Strategic Capital Project

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## Buried Piping Program Scope

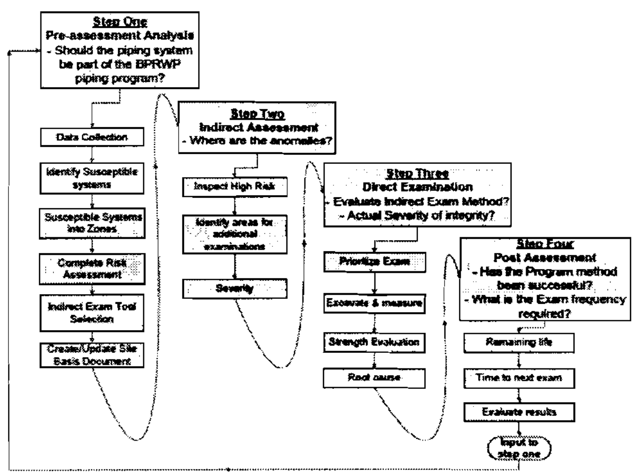


Figure 1: Four-Step Process for the Buried Pipe and Raw Water Piping Program

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# Step 1 Pre-Assessment Analysis

- ✓ **Buried Pipe Governing Procedures**
  - Buried Piping Program Guide
  - Raw Water Corrosion Program Guide
  - Buried Piping Exam Guide
  - Buried Piping Performance Indicators
- ✓ **Risk {R}** defined as: **R = Susceptibility x Consequences**
  - ❑ **Susceptibility factors:**
    - o Is cathodic protection applied
    - o Leak history
    - o Age of coating, condition of coating
    - o Location: Under tracks, roadway, building penetration (depth)
    - o Process fluid
    - o Soil
  - ❑ **Consequence Factors:**
    - o Safety
    - o Piping contains environmentally sensitive fluids (Rad-Waste, tritium, fuel oil)
    - o LCO associated with the piping (SR Service Water)
    - o Lost production required to repair (high repair cost)

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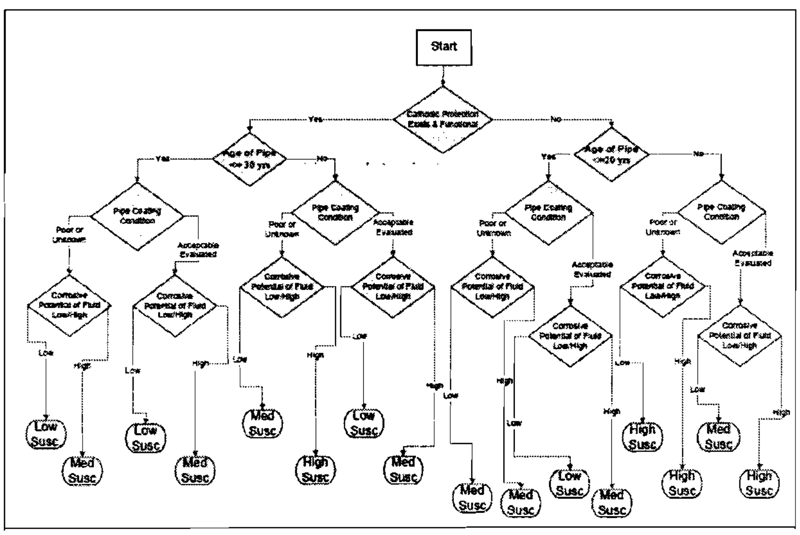
Figure 4B. Buried Pipe Susceptibility Flow Chart

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## Step 2 Indirect Assessment Methods

| Inspection Method | Purpose | Key Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Under paved roads | Shielded corrosion activity | Near River/ Water | Cased piping | Parallel pipe-line | Stray Current | Deep | Under High AC volt |
| Close Interval Survey (CIS) | Assess effectiveness of CP system | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 |
| Electro-magnetic | Locate coating defects | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 |
| Pearson | Locate coating defects | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| Current Voltage Gradient (ACVG DCVG) | Locate coating defects | 3 | 3 | 3 | 3 | 1,2 | 1,2 | 2 | 1,2 |
| C-Scan (AC) CICOS | Locate coating defects | 2 | 3 | 2 | 3 | 1,2 | 1,2 | 2 | 3 |
| Torsional Guided Wave | Wall thickness survey | 4,6 | 4,6 | 3,6 | 4,6 | 4,6 | 4,6 | 4,6 | 4,6 |
| Remote Field Eddy Current (RFEC) | Pitting & Wall thickness | 4, 5 | 4,5 | 4,5 | 4,5 | 4,5 | 4,5 | 4,5 | 4,5 |

1 = Applicable: capable of locating small holidays in coating (isolated and < $1in^2$), and conditions that do not cause CP fluctuations
2 = Applicable: capable of detecting large (isolated or continuous) coating holidays
3 = Not applicable to this method without additional considerations.
4 = Wall thickness survey G-wave and RFEC only.
5 = RFEC requires access to (pitch), pipe internal, and needs an exit point. Tool must traverse the length of pipe inspected. Pipe may need to be taken out of service.
6 = The G-wave signal becomes more attenuated as overburden becomes greater; therefore, the effectiveness decreases.

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## Step 3 Direct Assessments

✓ Buried Piping: External Corrosion
- Excavations have significant impact on plant operations
- Coating evaluation
- NDE: Piping Prep, UT, Pit depth, extent

✓ Raw Water: Internal Corrosion
- NDE Piping Prep, UT, RT
- Plant OE; external corrosion above ground interfaces

✓ Contingencies required to be in place
- Pre-assessment corrosion (flaw) handbook
- Parts / materials

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## Step 4 Post Assessment

- ✓ Corrosion Rate is the key
- ✓ Remaining Life
- ✓ Time to next inspection
- ✓ Effectiveness of inspection methods
- ✓ Update the Database & Program documents
- ✓ Repair/Replace Recommendations

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## Exelon Experience 2009

- ✓ **Experience in proactively identifying degraded piping using indirect assessment methods.**
- ✓ **Failures related to:**
  - Age of piping
  - Coating condition
  - Initial construction backfill conditions
  - Effectiveness of cathodic protection
- ✓ **Development & application of new NDE techniques and associated limitations**
- ✓ **Repair technologies**
  - Cured in place
  - Carbon fiber wrap
  - Traditional methods

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## Short and Long Term Plans

✓ **Short Term (<3 years):**

- Continue with program of indirect assessment and follow-up direct assessment as degraded segments are identified
- Optimize Cathodic Protection Systems
- Mitigation of known buried piping system vulnerabilities
- Initiate use of high density polyethylene (HDPE) on buried piping for long term corrosion prevention
- Plan for proactive replacement/mitigation of high risk buried piping segments

✓ **Long Term (>3 years):**

- New Technology Inspection Applications to complete initial indirect assessment of high risk buried piping
- Incorporate use of high density polyethylene (HDPE) on Buried ASME Class 3 piping for long term corrosion prevention and to minimize risk
- Plan for large scale repairs/replacements projects with corrosion resistant materials and to improve operational flexibility

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## Challenges/Barriers/Gaps

✓ **Original Design Practices**

- Building construction over piping, inaccessible piping
- Poor original cathodic protection design
- Piping not designed for current inspection methods
  - No access to piping internals
  - Concrete encased
  - Piping depth up to 35 feet
  - Insulated flanges

✓ **Importance of Cathodic Protection not fully recognized**

✓ **Contingencies for Buried Piping Work**

- Applying new inspection technologies (non-code) to effectively inspect buried piping
- Challenge for timely repair of degraded piping

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## Summary

- ✓ Exelon has changed approach—more proactive
- ✓ Exelon is inspecting buried piping at all sites with a formal program consistent with industry approach
- ✓ Inspections of buried inaccessible piping is a challenge and new technology is being developed
- ✓ Approval of corrosion resistant material for repairs and replacements needed for long term plans
- ✓ Long term repair/replacement projects being identified to improve the reliability of high risk piping

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