

## Entergy Operations, Indian Point Energy Center

United States Nuclear Regulatory Commission Official Hearing Exhibit	
In the Matter of:	Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3)
	ASLBP #: 07-858-03-LR-BD01
	Docket #: 05000247   05000286
	Exhibit #: NYS000179-00-BD01
	Admitted: 10/15/2012
	Other:
	Identified: 10/15/2012
	Withdrawn:
	Stricken:

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# Root Cause Analysis Report

CST Underground Recirc Line Leak

CR-IP2-2009-00666

REPORT DATE: 05-14-2009, Rev. 0

<b>Root Cause Evaluator:</b>	Anthony DeDonato	5/14/09
<b>Team Leader (optional)</b>	Steve Manzione	5/14/09
<b>Reviewer:</b>	Bob Sergi	5/14/09
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(APPROVALS ABOVE REQUIRED BEFORE CARB REVIEW)		
<b>CARB Chairman:</b>	Pat Conroy	5/14/09

*Authenticated by Electronic Signatures in PCRS (LI-118, [3.0](8) b.3)*

# Problem Statement

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"On February 16, 2009, Unit 2 entered a 7 day shutdown AOT due to an underground leak in the condensate storage tank return line."

## Team Members

Team Lead	Steve Manzione
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# Event Narrative

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On February 15, 2009, a CR was entered at 1629 EST. An Operator observed water filling the floor guard collar on the CST return line and spilling onto the floor on the 18' AFB pump area. Operations secured recirculation of CST-Hotwell. The Chemistry Department was contacted for sampling the spilling fluid. The Chemist reported 54ppb of Hydrazine in the water, which identified the water as condensate. CST was declared inoperable on Monday, February 16, 2009 at 0205 EST. Unit 2 was operating at 100% Rx power throughout the event.

The source of the leak was determined to be just outside of the Auxiliary Feed Pump Room (AFPR) based on observations of the leakage at the pipe collar in the AFPR, the leakage observed from Manhole #5 just outside the AFPR door, and Engineering experience and judgment of the leak to be near a pipe bend. Work forces were mobilized and boring through the concrete slab and excavation of the pipes was commenced. The area was full of water, just below the concrete slab. A vacuum truck was used to remove the water and fine debris from the area. Larger objects were removed by hand.

Workers reported the material was mostly clay under the floor. There was no evidence of any sand around the pipes. Some construction debris was also unearthed. Based on the condition of portions of the coating, the through wall leak and other defects on the pipe, a decision was made to replace the section of the pipe.

## Timeline of Major Events

Sunday, 2/15/09 @ approximately 1500

Water was identified leaking into the IP2 Auxiliary Feedwater Pump Building through a vertical pipe sleeve for the 8 CST return line.

Sunday, 2/15/09 @ approximately 1600

Chemistry results show 54ppb Hydrazine, which indicates it is condensate. The FSS contacts the Engineering Duty Manager (EDM). A conference call is held between Engineering management and supervisors.

Sunday, 2/15/09 @ approximately 1900

The EDM arrives on site, inspects the pipe sleeve, confirms water is rising up and requests another chemistry sample for confirmation of condensate.

Sunday, 2/15/09 @ approximately 2100

Further Engineering inspection reveals water is leaking into Manhole #5 at two locations through the masonry joints. (Manhole #5 is located in the FRV Room approximately 5' west of the underground location of the 8" line.) The Watch Chemist is instructed to take samples of incoming flows into Manhole #5.

# Event Narrative

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## Timeline of Major Events (continued)

Monday, 2/16/09 @ approximately 0205	The CST was declared inoperable and entered the 7-day AOT. Chemistry samples confirm the water is condensate in both the pipe sleeve and the effluents entering Manhole #5. The group decided to meet at 10:00 AM the following morning.
Monday, 2/16/09 @ approximately 1200	Civil Engineering maps out the line location underground and determines the area to be excavated based on the configuration of the pipe. Construction is mobilized.
Monday, 2/16/09 @ approximately 1900	Core drilling operations commenced in preparation of slab removal for excavation of the area. First indications that water saturation is present under the slab. Demolition by jackhammer is not allowed due to possible undermining.
Monday, 2/17/09 @ approximately 0500	Core drilling operations in progress; the first 2' x 2' section of the slab is removed. Standing water is present under the slab. Three small sump pumps are needed to keep up with the water.
Monday, 2/17/09 @ approximately 1700	Removal of the concrete slab was completed.
Tuesday, 2/17/09 @ approximately 2200	Shoring is installed in the excavation; a containment area for removed soil is set up.
Tuesday, 2/17/09 @ approximately 2400	The vacuum truck arrives on site.
Wednesday, 2/18/09 @ approximately 0230	Excavation of the site begins.
Wednesday, 2/18/09 @ approximately 1800	Chemistry increases the amount of Hydrazine in the Condensate System and monitors the level of Hydrazine in the area.
Wednesday, 2/18/09 @ approximately 2100	Operations calculates the make up to the CST is approximately 17gpm. Chemistry confirms the leak in the 8" line to the CST based on rising Hydrazine levels in Manhole #5.

# Event Narrative

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## Timeline of Major Events (continued)

Thursday, 2/19/09 @ approximately 0100	12” pipe is exposed and no leakage is seen.
Thursday, 2/19/09 @ approximately 0330	8” pipe is exposed and the leak is seen at the horizontal section of the pipe.
Thursday, 2/19/09 @ approximately 0400	Engineering assesses the leak is located at the 5:00 position of the pipe and determines the pipe is structurally sound to accept a housekeeping patch.
Thursday, 2/19/09 @ approximately 0600	A full circle clamp with longer bolts is installed over the leak; it slows it down enough for the sump pumps to keep up with dewatering, allowing further inspections.
Thursday, 2/19/09 @ approximately 1200	Abatement of the coal-tar coating begins.
Thursday, 2/19/09 @ approximately 2100	Abatement is completed; visual inspection and UT of the line is started.
Thursday, 2/19/09 @ approximately 2230	Visual inspection and UT of the line is completed. Several areas of minor degradation were found on the lower elbow and horizontal section of the pipe. A decision was made to replace the elbow and damaged section of the pipe.
Friday, 2/20 @ approximately 0100	Shop work on the replacement pipe is started.
Friday, 2/20 @ approximately 0500	Shop weld is completed. NDE was performed on the weld, MT SAT.
Friday, 2/20 @ approximately 0500	Entered a 72-hour AOT for 22ABFP in order to accommodate the pipe and elbow replacement and isolated line #1509.

# Event Narrative

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## Timeline of Major Events (continued)

Friday 2/20/09 @ approximately 1200	Pipe and elbow section removed.
Friday 2/20/09 @ approximately 1700	Pipe fitted into place. Weld out of two field welds begins.
Saturday 2/21/09 @ approximately 0400	Work completed, NDE performed, MT reading SAT, Operations commence clearance of PTO and filling line.
Saturday 2/21/09 @ approximately 0530	Line verified fill, in service VT-1 leak inspection performed by Operations; no leaks observed.
Saturday 2/21/09 @ approximately 0600	ABFP 22 declared operable, exited the 72-hour AOT.
Saturday 2/21/09 @ approximately 0630	CST Line declared operable, exited the 7-day AOT. All work secured.

# Event Narrative

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## Background Information

- Lines 1505 and 1509 are carbon steel, schedule 40. Line 1505 is the 12” supply from the CST to the AFPs. Line 1509 is the 8” CST return line. These lines were deemed not to require cathodic protection during original plant design due to favorable soil resistivity and drainage characteristics. As a defense against localized corrosion attack, however, lines 1505 and 1509 were externally coated with coal tar enamel and have a coal tar enamel saturated felt overwrap. These pipes are sloped from the CST elevation to the AFPB, and are each approximately 320-330 feet in length.
- Several months prior, a similar event occurred when water was observed at the same pipe sleeve. Excavation of the CST lines at 2 locations was in-progress at this time of inspection. The leak was attributed to groundwater due to the open excavations. No hydrazine was detected. This was based on Chemistry testing for activity, pH and hydrazine.
- The backfill that was used in this area during original installation contained various size rocks and other foreign material such as cans and wire. The backfill used was for a light load area.
- Groundwater is suspected to also infiltrate the area.
- Line 1509 does not experience “movement”. The buried pipe is installed below the freeze line. Other than seismic activity, there is no ground movement accounted for in the design nor anticipated to occur. Thermal expansion is very small due to the small delta T that may be experienced if the water from the CST was at its high temperature of approximately 100 degrees °F. However, thermal growth would not cause pipe movement since the pipe is restrained by the ground in the vertical rise at both ends.
- The area is used as a walkway. If there is significant heavy load on top of the slab and the fill has 3” to 8” large rocks (confirmed by observers), the heavy load can force the pipe to deflect downward and pinch on the rock, causing damage to the coating.
- Underneath the 6’x 6’ cut hole on the floor slab, the fill was washed out locally.
- AFW building is supported by the foundation and containment building wall. The foundation is into the bedrock and loss of fill will not affect the load transfer capability from the slab, to the wall, to the foundation and onto the bedrock. The containment mat foundation is into the bedrock and will not be affected by the leak.

# Event Narrative

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## Background Information (continued)

- Sections of the bituminous type wrap were discovered damaged some voids around the area of the leak and 90° elbows.
- The specific 1989 ASME Code requirement to be met for the buried pipe #1509 is IWA-5244(c) which requires verification of non-impairment of flow in the non-isolated and non-redundant line to the heat sink. This specific requirement is met by performance of a pump test which verifies the ability to obtain and control recirculation flow. This inspection is required to be performed three times within the 10 year interval. Successful performance of PT-Q34 in conjunction with the PI-3Y4A Inservice Inspection services as verification of non-impairment of flow.
- Seismic concerns: based on outside study, historical seismic activities around IPEC from 1974 until 2007 fell into a range of modified Mercalli scale of 2.4 to 3.0. The range of seismic activity at the plant is less than 3.0 (0.007g) and IPEC is designed to M = 6.5, well below the plant's design ground response spectrum. The leak location has exterior surface/coating damages that appeared to be caused by impact from large, angular external object. It is highly unlikely that uniform seismic ground movement with a buried pipe could cause such a surface impact.
- An Entergy Engineering Fleet Call was conducted on March 4, 2009, which discussed the failure of the CST return line #1509.

## CST Operation and Secondary leak detection

The condensate Storage Tank (CST) supplies makeup water to the Condensate System and to the Auxiliary Feed Water Pumps (AFP) during hot shutdown decay removal via a common 12" underground pipe. The CST is sized to supply a minimum inventory of 360,000 gals for 24 hrs of decay removal in hot standby following a plant trip as well as additional inventory for Condensate operation. This 12" supply line first feeds an 8" common AFW supply header in the ABFP, and then is routed to the Turbine Bldg via LCV-1158 which will automatically isolate make up to the Condensate System to protect this minimum inventory for AFW in this 600,000 gal design capacity tank. An 8" return header off condensate pump discharge is routed underground back to the CST for inventory control. AFPs recire back to the CST via individual 3" lines that tap into this 8" Condensate Return header to maintain minimum design pump flow whenever running AFPs are not feeding Steam Generators.

Normal operational lineup in the Turbine building is as follows, the CST supply valves (LCV-1127 & 1128A) to the condenser hotwells are throttled open in manual control. Condensate System return is controlled in manual via LCV-1129 which is normally kept shut in warm weather. In the winter, LCV-1129 is throttled open to maintain CST temperature between 50 and 65°F. Summer CST temperatures can range in the 80's.

# Event Narrative

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## CST Operation and Secondary Leak Detection (continued)

A mobile unit supplies primary water to U2 via portable demineralizers to the three U1 Condensate Storage Tanks. From here, water factory Deaerator Booster Pumps supply U2 condensate makeup to the Drains Collecting Tank (normal path) or to the U2 CST. Flow to the Drains Collecting Tank (DCT) is adjusted using Booster Pump (BP) flow (FI-531) or Primary Water Flow to the DCT (FIT-10001) meters for rough monitoring of manual changes.

Operators control secondary makeup by monitoring average Hotwell level in the Control Room. They attempt to match BP flow to the DCT with condensate losses. These losses include 100 gpm S/G Blowdown (or 70 gpm cold), 20 gpm Aux Steam heating (winter), 10-20 gpm condensate leakage and steam loss. Other than S/G blowdown there are no meters to track process losses. Operators allow CST level to track down slowly to makeup for the difference between DCT supply and secondary losses

Operations initially estimated the return line loss at 17gpm by shutting LCV-1158 and 1129 and subtracting the difference in CST rates of level change. This assumes no leak by LCV-1158 and no siphon break in the Return line.

A 10 gpm loss equals 14,000 gallons a day. This equates to a CST level loss of 9 in/day or 3/8 in/hr. This would be hard to detect by monitoring CST level changes because the indicator in the CCR has intervals of feet, and such small changes cannot be visibly seen unless tracked over a few days. Since the CST is not the primary means of making up secondary losses, a 10 gpm leak would go unnoticed by watching CST levels. Hotwell level is maintained at about 4' or 76,000 gals. At 19,000gal/ft., a 10 gpm loss equates to about 3/8 in/hr change in hotwell level. Since operators maintain hotwell level within a close band, leak rate changes can't be detected by hotwell level.

# Event Narrative

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## IPEC Buried Piping and Tank Inspection and Monitoring Program

The IPEC Buried Piping and Tank Inspection and Monitoring Program, hereafter simply referred to as BPT Program, is under development. The foundational elements of the program have been completed per scheduled milestones identified in Entergy fleet procedure EN-DC-343, which went into effect on Nov. 19, 2007. The fleet procedure required that all systems having buried portions of piping be included in the program, including but not limited to those systems that were identified in the IPEC License Renewal Application (LRA).

Once all buried piping systems were identified, the piping was assessed as having High, Medium or Low Impact, based on the consequences of a failure of the piping in the following areas:

- Safety (High = Nuclear Safety Related; Medium = Augmented Quality/Category M; Low = non-safety related)
- Public risk (High = potential radiological consequence; Medium = environment discharge or hazardous fluid; Low = non-contaminated, non-hazardous fluids)
- Economic impact of equipment failure on plant operation (High = >\$1M; Medium = \$100K - \$1M; Low = <\$100K.)

Table 1 presents the details for performing the impact assessment.

Using the impact assessment results, the High Impact systems are Corrosion Risk assessed with consideration of the following four (4) factors:

1. Soil resistivity
2. drainage
3. material
4. coatings/cathodic protection.

Tables 2 and 3 present the details for performing the corrosion risk assessments. Corrosion risk assessments were performed sequentially for the High, Medium and Low Impact system.

# Event Narrative

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## IPEC Buried Piping and Tank Inspection and Monitoring Program (continued)

In conjunction with the corrosion risk assessments, the inspection priorities for performing the initial inspections and subsequent inspection intervals were determined for each buried piping system based on the results of the Impact and Corrosion Risk assessments. Table 4 provides the guidance for scheduling these inspections.

Buried pipe inspection parameters will include:

- External pipe coating and wrap condition
- Pipe wall thickness
- Cathodic Protection effectiveness (if applicable)

Current plans are for a Central Engineering Programs document for buried pipe and tanks be developed (target issue by end of 2009), and for each site to manage its buried pipe activities (surveys, excavations, inspections, etc.) using IDDEAL Scheduleworks, or similar software.

IPEC License Renewal Application (LRA) commitments for Buried Piping and Tanks Program:

IP2	Commitment NL-07-039	Sept. 28, 2013
IP3	Commitment NL-07-153	Dec. 12, 2015

The excavations and inspections of the IP2 AFW lines to the CST were performed in response to the ISE Panel recommendation to complete same by the end of 2008.

# Event Narrative

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## Utility Experience

Most utilities are in the process of early Buried Piping and Tank Program development. Some (as IPEC, in 2005) have received INPO AFI's for non-functioning Cathodic Protection systems for their buried piping.

At IPEC, however, Cathodic Protection systems are generally not provided for buried piping systems (exceptions being the sewage treatment pipeline, and underground diesel fuel oil lines). Resolution of the IPEC AFI is focused on correcting deficiencies in the installed cathodic protection system.

According to the Unit 2 and Unit 3 USFARs, the basis for not providing cathodic protection systems for buried piping was an engineering study performed during original licensing of the plants. Determinations of the soil resistivities at locations away from the river were concluded to be sufficiently high to preclude the need for cathodic protection for buried piping. The study recommended the application of protective coating to prevent local corrosion attack. Based on recent resistivity testing, the original resistivity determinations remain consistent.

An EPRI guidelines document (1016456) for an effective buried pipe program was issued in Dec. 2008. Future revision to the document is planned and will include:

- Buried tanks
- Non-metallic pipe

Industry initiatives are being taken to identify underground piping assessment technologies to perform assessments of coating integrity/condition, to identify degraded pipe locations and to quantify associated wall loss.

The EPRI buried piping guidance document has identified several methods that are used in the gas and oil pipe lines industries, but has not endorsed them.

# Event Narrative

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**Table 1 – Impact Assessment**

	High	Medium	Low
Safety (Class per EN-DC-167)	Safety-related	Augmented QP and Fire Protection	Non-Safety related
Public Risk	Radioactive Contamination e.g. Tritium	Chemical/Oil-Treated System Gases	Untreated Water, SW, Demineralized Water
Economics (Cost of buried equipment failure to the plant)	> \$1M or potential shutdown	\$100K - \$1M	< \$100K
Notes:	<ol style="list-style-type: none"> <li>1. Any buried section with at least one High Impact gets an overall High Impact rating.</li> <li>2. Any buried section with no High Impact rating but at least one Medium Impact rating gets an overall rating of Medium Impact.</li> <li>3. Any buried section with all Low Impact ratings is to be rated as Low Impact.</li> </ol>		

# Event Narrative

**Table 2 – Corrosion Risk Assessment**

Soil Resistivity Ω-cm (Note 1)	Corrosivity Rating	Soil Resistivity Risk Weight
> 20,000	Essential Non-Corrosive	1
10,001 – 20,000	Mildly Corrosive	2
5,001 – 10,000	Moderately Corrosive	4
3,001 – 5,000	Corrosive	5
1,000 – 3,000	Highly Corrosive	8
< 1,000	Extremely Corrosive	10
Drainage		Drainage Risk Weight
Poor	Continually Wet	4.0
Fair	Generally Moist	2.0
Good	Generally Dry	1.0
Material		Material Risk Weight
Carbon and Low Alloy Steel		2.0
Cast and Ductile Iron		1.5
Stainless Steel		1.5
Copper Alloys		1.0
Concrete		0.5
Cathodic Protection	Coating	CP/Coating Risk Weight
No CP	Degraded Coating	2.0
No CP	Sound Coating	2.0
No CP	No Coating	1.0
Degraded CP	Degraded Coating	1.0
Degraded CP	Sound Coating	1.0
Degraded CP	No Coating	0.5
Sound CP	Degraded Coating	0.5
Sound CP	Sound Coating	0.5
Sound CP	No Coating	0.5

Note: Soil resistivity measurements must be taken at least once per 10 years unless areas are excavated and backfilled or if soil conditions are known to have changed for any reason.

# Event Narrative

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**Table 3 – Corrosion Risk Tabulation**

Corrosion Condition	Risk Weight Points
Soil Conditions Resistivity Drainage	1 – 10 1 – 4
Materials Material	0.5 – 2
Component Protection Cathodic Protection / Coating	0.5 – 2
Final Corrosion Risk Tabulation Multiply all weights together in Steps 5.5 [2] (a) thru (d)	0.25 – 160

Corrosion Risk:      High            61 – 160 points  
                              Medium        30 – 60 points  
                              Low            0 – 29 points

# Event Narrative

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**Table 4 – Inspection Intervals vs Inspection Priority**

Impact – Corrosion Risk	Inspection Priority	Initial Inspection (Years)	Inspection Interval (Years)
High-High	High	5	8
High-Medium	High	5	8
Medium-High	High	5	8
High-Low	Medium	8	10
Medium-Medium	Medium	8	10
Low-High	Medium	8	10
Medium-Low	Low	10	15
Low-Medium	Low	10	15
Low-Low	Low	10	15

Notes:

1. High priority initial inspections shall be scheduled within 5 years. Subsequent high priority inspections shall be scheduled within 8 years thereafter.
2. Medium priority initial inspections shall be scheduled within 8 years. Subsequent medium priority inspections shall be scheduled within 10 years thereafter.
3. Low priority initial inspections shall be scheduled within 10 years. Subsequent low priority inspections shall be scheduled within 15 years thereafter.
4. Regardless of the above inspection schedule (reference EN-DC-343), compliance with IPEC LRA commitments prevail.
5. Once initial inspections are performed and conditions before known, a re-prioritization may maintain, decrease or increase a component future inspection priority.

The CST line (#1509) was assessed per EN-DC-343 to be a “High” inspection priority.

# Event Narrative

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## Previous Inspections of CST 8" Line

As a result of the Indian Point Independent Safety Evaluation (ISE) Report dated July 31, 2008, the following recommendation (R-7) was issued via LOCR IP3LO-2008-00151, CA-19: "to explore options for reducing the vulnerability of buried piping to the occurrence of any future unanticipated leak. Such options include excavating a few selected locations to confirm the presence of protective coating on the piping, as well as to measure and confirm the existence of sufficient wall thickness of the thus exposed piping using existing inspection techniques." Two areas of the Unit 2 CST lines were selected for inspection. The following information was retrieved from CR IP2-2008-04754.

The three CST pipes (Aux Feed Pump supply, CST return and CST overflow) were exposed at two locations for approximately 10' piping runs each.

The three inspected lines were: 12" Line 1505, AFP Suction line,  
8" Line 1509, Condensate supply to the CST  
10" Overflow Line (no line number assigned, corrugated metal pipe to Manhole #5

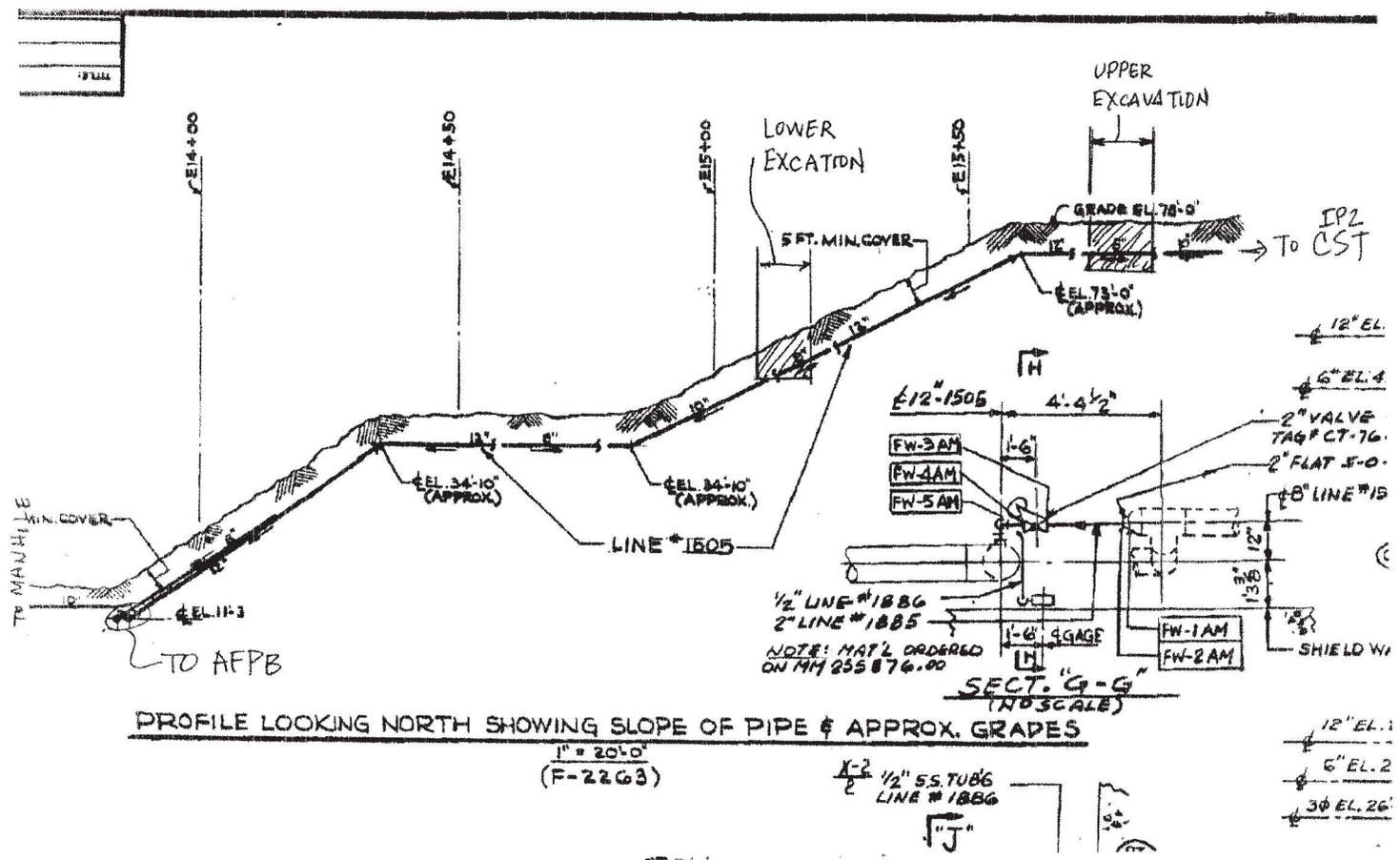
Upper and lower holes were excavated. An inspection in the upper hole identified five areas which required coating repair. UT thickness measurements were also performed on those areas where the base metal was exposed and these inspections confirmed that the pipe thickness remains at nominal thickness (i.e. within the manufacturer's tolerance). All of these activities were performed under WO 164495.

The visual inspection of these pipes at the lower excavation revealed that they were in generally good condition, with the coating intact and in acceptable condition. A minor coating repair was required at one location on 8" Line 1509 and the 10" overflow line required repair at the top portion of the pipe at the crests of the corrugations, possibly indicative of coating damage during the digging. Based on the results of these pipe visual inspections (at the upper and lower holes), and the coating repairs performed, there was no evidence of any significant pipe degradation that would warrant the re-inspection of these pipes at the same locations. Future inspection of these lines will be performed at different location(s) along their length. The scheduling of the future inspections will be controlled under the IPEC Buried Pipe Program. Specifically for the CST lines, CA-5 of CR IP2-2008-04754 reads, "Given the results of the leak in the AFP Building, determine if the scope and/or frequency of future buried condensate lines should be modified. This should cover both IP2 and IP3." See elevation drawing on the next page.

Completed assessments of these lines determined these lines to be of HIGH impact (two lines are safety related), MEDIUM corrosion risk and HIGH inspection priority. The HIGH inspection priority results from the safety function performed by Lines 1505 and 1509. The pipe material, soil resistivity and site condition factors result in these lines being of medium corrosion risk. Accordingly, with the initial inspection of these lines performed in October/November 2008, re-inspection of these lines is required within eight years, or by September 2016.

LO-14310-2008-151 CA-14  
ATAch 2  
2/2

LINES INSPECTED  
12" LINE 1505  
8" LINE 1509  
10" OVERFLOW LINE (CORRUGATED METAL PIPE)



PROFILE LOOKING NORTH SHOWING SLOPE OF PIPE & APPROX. GRADES

# Event Narrative

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The configuration of the underground structures in the area is laid out as follows:

The ABFP Building column wall #22 is a solid concrete wall anchored directly to the bedrock that spans from the east wall to the west wall. The ABFP Building wall begins at approximately the 12' elevation (6' below grade) and is connected to the containment shield wall on the east end and the ABFP shield wall on the west end. The column wall #21 is a solid wall anchored directly to the bedrock. The east wall running north to south does not penetrate below grade. The west wall running north to south does not penetrate below grade but the structure for Manhole #5 is located in this area. There are two concrete slabs under the pipes in this area. One is the pad for the stairs and the other is believed to be related to Manhole #5. They are between 4-8" below the pipe. Based on this, the area can be described as being similar to a "bath tub" that drains slowly.

The slab construction in this area is approximately 6-8" thick and was poured as a monolithic slab on grade with sporadic reinforcement installed. There was one area that had what appeared to be 6 x 6 welded wire mesh. But it was not consistent throughout the slab and was not heavily supported when the slab was originally poured. This arrangement would not be unusual for a walkway design.

Once excavation began, it was apparent that there was significant amount of standing water beneath the slab and the backfill was saturated. The backfill also had significantly reduced in volume and was not supporting the slab in this area. The gap between the slab and top of the backfill was approximately 6" to 10", covering an area approximately 8' x 8'. There also was an area that appeared to be washed out measuring 2' x 2' and greater than 6' deep.

The backfill in the area contained rocks measuring up to 8" and other debris such as several aluminum cans and other debris. The large rocks were found throughout the excavation area and a concentration was found closer to the pipe, especially in the area of the 2' x 2' sinkhole. The debris and rocks would hamper the achievement of proper compaction of the area due to the creation of voids and an increase in the amount of un-compactable material.

The configuration of the underground structures that encompass the area allows some ground water to collect due to run off from the north hill and surrounding area. The elevation of the 8" pipe is estimated to be at or just above the groundwater table area; this is based on the surveys of the installed test wells in the area. Some groundwater infiltration has been seen leaching into the bottom of the excavation site, creating a wet environment around these lines.

The 12" line (#1505) and the 8" line (#1509) are carbon steel, schedule 40. These lines were deemed not to require cathodic protection during original plant design due to favorable soil resistivity and drainage characteristics. As a defense against localized corrosion attack, however, lines 1505 and 1509 are externally coated with coal tar enamel and utilize a coal tar enamel saturated felt overwrap for further protection of the coating.

It is a general coating practice to pull a glass matt into the hot enamel as reinforcement, and the outer side of the coating is saturated asbestos felt. The same corresponding lines at Unit 3 are above ground, insulated and heat traced, except outside the ABFB as described on page 35.

The bituminous coatings, as a class, are the most widely used protective media. These classes include asphalt enamels, the greases or waxes, and other mastics which consist of an asphalt or coal-tar base plus an inert binder. Of the large group of coatings tested under the joint effort of the National Bureau of Standards and the American Petroleum Institute, concluded that asphalts and coal-tar enamels were the best.

# Event Narrative

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Coal-tar coatings have been used for over 100 years to protect ferrous metals against underground corrosion. In 1913, an early form of coal-tar enamel was used in protecting gates, locks and penstocks of the Panama Canal. Examination after 35 years of service showed them to be in perfect condition. Coal-tar pitch is almost completely inert to moisture and soil chemicals. Coal-tar coatings and coal-tar pitch used as pipe coatings and for waterproofing have been dug up after 20 to 50 years of service underground. Coal-tar pitch does not absorb any appreciable water and is not affected to any appreciable extent by soil bacteria. These properties make it eminently more suitable for waterproofing and coating of buried steel pipe lines to protect them from the corrosion action of wet soil. If properly applied, the coating should be able to protect the lines in their currently installed environment and is within the life span of the protective coating.

Flow accelerated corrosion (FAC) was not part of the failure mechanism as described below.

Flow accelerated corrosion of carbon steel in water occurs due to the dissolution of the normally protective magnetic film that forms on the surface. (Mechanical removal, i.e. cavitation-erosion, does not normally occur under FAC conditions.) This corrosion was outside to inside on the pipe, and temperature attributes for FAC are generally between 212 °F and 572 °F.

The leak in the condensate piping was caused by external corrosion. Patterns of corrosion on the piping and observations of the backfill indicate that the corrosion on the pipe likely occurred at localized areas of coating damage that occurred during installation of the pipe. In comparison, other corrosion found on the removed elbow which affected a larger area but it was not as deep is more typical of corrosion related to difficulties in applying a good quality coating on more complex surfaces such as elbows and other fittings. For additional details on the failure analysis, see Structural Integrity Associates (SIA) Report No. 0900235.402.

# Event Narrative

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## Conclusions

From the information gathered, the event was caused by the failure of the protective coal-tar epoxy coating that was applied at the time of original construction. Based on historical data, the coating, if properly applied, remains undamaged is sufficient to provide corrosion protection of the pipe. This is based on outside studies and the results of the previous inspection and analysis performed in 2008.

The coating failure was a direct result from the installation and type of backfill.

The eventual location of the “through wall leak” on the straight horizontal pipe at this location was due to a localized coating failure in this area that made it the most susceptible area to degrade once the mechanism for corrosion started. There were other localized areas on the straight pipe section and 90° elbow that were in a very advanced state of corrosion, also would have, given more time, would have eventually produced additional leak locations.

The ground water infiltration, soil composition, and the location of the leak at the lowest point of the system were all contributing factors to the leak developing in this area.

# Root Cause Evaluation

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The **Direct Cause (DC)** was a through-wall defect in the CST return line located below grade in the ABF Building. There is evidence that the pipe coating had degraded allowing corrosion to eventually penetrate its way through the pipe wall.

## A. ROOT CAUSE(S)

1. **RC<sub>1</sub>** - The Root Cause (RC-1) is the installation specification 9321-01-8-4 in effect at the time of plant construction. There is evidence that sections of the pipe coating were damaged by rocks that were present in the backfill for the CST lines. The pipe coating material is fiber-based saturated with coal-tar. The material is then applied to the pipe. Since it is a fiber, the coating is susceptible to damage from the various size rocks found in close proximity to and in some cases, up against the pipes themselves.

The rocks present in the backfill caused coating degradation in some areas of the pipes, making the pipes susceptible to external corrosion. It is evident that soil conditions influence the corrosion rate on those sections of pipe where there is coating degradation. For example, in the sample inspection holes, some coating degradation was found accompanied by minor surface rust. Ultrasonic Testing (UTs) of these areas found virtually no pipe wall loss. The soil conditions in the sample inspection holes were mostly dry, with minimal ground water present. By contrast, the soil in the failure location was found to be moist, which is consistent with the water table in the area estimated to be at the eight to ten foot elevation. The absence of gravel and sand surrounding the pipe promotes wicking of the ground water through the soil which also contributes to the moist conditions in the area. Therefore, the combination of degraded pipe coating and high water table served to accelerate corrosion of the failed pipe.

# Root Cause Evaluation

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## **B. CONTRIBUTING CAUSE(S)**

CC<sub>1</sub> – The water table in the area of the leak is between eight to ten feet with the pipe elevation at approximately ten feet. The backfill specification did not specify the use of clean sand and gravel under the pipe that would have limited the wicking of the ground water to the soil surrounding the pipes. This kept the soil in the area moist, and at times wet. These soil conditions would find its way into defects in the coating causing corrosion external to the pipe.

CC<sub>2</sub> – The inspection techniques used to preemptively detect underground pipe through wall leaks was ineffective. Buried Piping and Tank Inspection and Monitoring Program does not identify the low point of a pipe line as a suggested sample test point. The procedure inspection locations are based on risk and impact assessments, ease of access, limitations of inspections and ability to isolate lines.

# Root Cause Evaluation

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## C. ORGANIZATIONAL AND PROGRAMMATIC WEAKNESS EVALUATION:

The team performed an Organization and Programmatic Issues Review in accordance with Attachment 9.5 of EN-LI-118.

### 1. Organization and Programmatic Issues for Installation Concerns

**OP2J** – Is there evidence that personnel exhibited insufficient awareness of the impact of actions on safety and reliability?

Yes. The drawings and specifications allowed the use of material (already available on site) from blasted areas as fill for this buried pipe.

**OP4A** – Is there evidence that there are insufficient details in a procedure to perform the task?

Yes, at the time of installation, UE&C Specification No. 9321-01-8-4, Placing and Compaction of Backfill, was used as backfill guidance. This spec only stated the following, “Place fill in 12” layers and compact with tamper in small areas or by dozer or trucks in open areas. Top 12” shall be clean and compacted as noted on drawings.” Drawing 9321-F-1002 states to “top off with gravel.” Drawing 9321-F-1024, Containment Building Backfilling and Grading North and East Side, has a note which reads, “Surface of fill to be random size blasted rock from Unit 3 excavation.”

Presently for Unit 2, Con Edison Specification 02200 governs excavation and backfilling. For Unit 3, today’s specification is UE&C Specification 9321-05-8-4, Placing and Compaction of Backfill, which is very similar to the original Unit 2 specification.

**OP5E** – Is there evidence of inadequate job skills, work practices or decision making?

Yes, there could have been the potential for poor job skills and work practices when applying the pipe coating, because the fill used was a contributor to the coating damage that was observed.

All of the above identified issues occurred over 30 years ago, and there are corrective actions to address them. Present equipment and construction specifications and quality control/assurance review, the Engineering modification process would minimize these occurrences from repeating themselves. Interim corrective actions will be issued with this report to address these concerns.

### 2. Organization and Programmatic Issues for an Inadequate Buried Pipe Program (EN-DC-343)

**OP4A** – Is there evidence that there are insufficient details in a procedure to perform the task?

Yes, EN-DC-343, Buried Piping and Tank Inspection and Monitoring Program does not identify the low point of a pipe line as a suggested sample test point. The procedure inspection locations are based on risk and impact assessments, ease of access, limitations of inspections and ability to isolate lines.

A corrective action to address this issue would be for the Entergy Fleet team to assess the addition of this point in the procedure, EN-DC-343.

# Root Cause Evaluation

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## **D. Safety Culture Evaluation**

The root cause and contributing causes were reviewed against EN-LI-118, Attachment 9.6, Safety Culture Evaluation. It was determined that 12 of the 13 impact areas were not applicable to the causes identified within this root cause analysis. However the Human Performance portion of the Safety Culture was impacted because complete, accurate and up-to-date Design Specifications were not in place during original backfill and supervisory and management oversight of work activities and contractors were not effectively implemented to prevent inappropriate backfill practices.

## **E. Equipment Failure Evaluation – see Attachment.**

# Generic Implications

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## Extent of Condition Review

As previously stated in this evaluation, the condition of the CST return line through-wall degradation and eventual leakage, was corrosion of the carbon steel piping material caused by coating imperfections and soil/ground water conditions.

Based on the cause of the corrosion and a review of the IPEC Buried Piping Program, it has been determined that all buried coated carbon steel piping could be susceptible to the same corrosion mechanism since the same materials and construction practices used to install the CST return pipe could have been used in other systems. Although all buried piping could be susceptible to external corrosion, recent inspections and operating experience indicate that piping buried at the lower site elevations could have a higher susceptibility because of the closer proximity to the ground water. This was confirmed by the Fall of 2008 excavations which indicated that piping with areas of degraded coating experienced essentially no degradation other than minor surface corrosion. On the other hand, the auxiliary steam pipe between IP1 and IP3, and the IP2 condensate return lines, experienced significant degradation in areas where the protective coating or insulation was either missing or degraded. In the case of the auxiliary steam piping, the incorrect type of insulation was installed (water retentive vs. water shedding). Both the IP2 CST return line and the auxiliary steam piping were buried under the 15' ground level while the two excavated locations were at the 60'+ elevation.

Unlike IP2, the piping at IP3 from the CST down to the transformer yard is supported above grade, heat traced and insulated.

The impact and risk assessments performed for the Buried Piping Program identified the following systems having buried piping that are deemed high priority for inspection:

<u>IP2</u>	<u>IP3</u>
City Water	City Water
EDG Fuel Oil	EDG Fuel Oil
Service Water	Service Water
CST Piping	CST Piping
	Aux Steam
	Steam Generator Blowdown

# Generic Implications

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## **Extent of Condition Review (continued)**

Those systems that are assessed to be medium inspection priority, have been scheduled in a long-term inspection plan, with a delayed first inspection (increased from 5 to 8 years) and longer interval until the second inspection (increased from 8 to 10 years).

Similarly, buried tanks of high inspection priority include the EDG fuel oil storage tanks for both IP2 and IP3. However, these tanks and associated piping are enclosed in concrete vaults and were provided with an engineered backfill and therefore, have reduced exposure to the environmental conditions that are associated with the failed lines and no radiological consequence of failure.

## **Extent of Cause Review**

The root cause of this event is attributed to backfill specification No. 9321-01-8-4 used for the buried CST pipe. The specification did not provide limits regarding the type of fill, including rocks size that could be used. Other backfill specifications in effect at the time of construction were also considered. These include backfill for the circulating water piping and de-icing line and around the containment building. A review of these specifications found them to be adequate for their applications.

Other installation specifications associated with Systems, Structures and Components (SSC) important to safety was also considered for deficiencies. These installation specifications were found to be not applicable based on years of operating experience and the plants surveillance test, predictive and preventive maintenance and corrective action programs. These programs are effective in the prediction and identification of equipment and component problems before they become self revealing.

Backfill specifications do not fall into the same category as the specifications mentioned in the previous paragraph. Inspections of buried components is presently limited through code based piping and tank tests. The IPEC buried piping program will address this issue of underground pipe inspections.

## **Proposed Corrective Actions (GI1)**

As stated above, a number of systems have buried carbon steel piping in locations where the soil conditions could be conducive to external corrosion.

Discussions with buried piping inspection vendors as well as EPRI and other utilities indicated that there are several methods which can be used to assess the condition of buried piping and/or the condition of the protective coating. The three most effective and most widely used methods are discussed below:

1. Guided Wave UT (GWUT) – This approach has been demonstrated by EPRI and by GWUT vendors to be an effective tool to identify areas of concern. For GWUT, an inspection collar is installed in an area of the pipe with known thickness. The GWUT collar then sends torsional and longitudinal sound waves down the pipe to compare the continuous cross sectional area of the pipe relative to the average cross sectional area under the collar.

# Generic Implications

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## Proposed Corrective Actions (GI1) (continued)

This provides a continuous assessment of the remaining pipe cross sectional area for pipe lengths up to several hundred feet, depending on the number of pipe fittings such as elbows located in the inspected area. In addition to the remaining cross sectional area, the GWUT also assess the uniformity of the cross section. This allows the inspector to determine whether any wall loss is uniform around the entire pipe circumference or whether it is predominantly concentrated at a location around the circumference. This inspection tool has been demonstrated to be effective in confirming the absence of corrosion and locating areas for additional inspection. However, since the GWUT does not provide actual pipe wall thicknesses, it can not be used to perform structural evaluations or assess piping operability.

2. Coating Assessment – This assessment technique uses electrical current to locate coating holidays. This method sends electrical current down the pipe from a given location (usually at the location where the pipe penetrates the ground) and then the inspector uses a special probe to walk the area above the pipe, to locate areas of stray current. The location and magnitude of the stray current areas provides an indication of the location and extent of coating degradation. Similar to the GWUT, this inspection technique is effective in locating areas for further evaluation but does not provide actual pipe wall thickness measurements to support structural evaluations. Therefore these inspection results can not be used to assess piping operability.

3. Direct OD Surface Inspection – This approach is the most effective in assessing the condition of the coating and also provides access to straight beam UT which allows for direct measurement of the remaining pipe wall thickness. However, this approach requires excavation ranging in depth from a few feet up to 20 or 25 feet, and has the potential for causing damage to the pipe and/or pipe coating during the excavation itself. This approach requires extensive resources and can not be used when the outside temperature has the potential to result in freezing. This approach is best used in combination with either GWUT or coating inspections when areas of concern have already been pre screened.

The recommended locations to be inspected are:

1. IP2 8” Condensate Return Line in the excavated area in the FRV Room.
2. IP2 12” Condensate Supply Line in the excavated area in the FRV Room.
3. IP2 24” SW Line 408 in the Transformer Yard outside the PAB where it exits the ground.
4. IP3 12” Condensate Supply Line outside the Auxiliary Feedwater Pump Building where it goes underground.
5. IP3 8” Condensate Return Line outside the Auxiliary Feedwater Pump Building where it exits the ground.
6. IP3 24” Line 408 in the backup pump valve pit.

NOTE: If any of the above area(s) are not accessible, substitute area(s) may be selected by IPEC Engineering.

# Previous Occurrence Evaluation

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## Internal

A search of internal operating experience data was performed to determine if the same or similar conditions had previously occurred at IPEC or other Entergy sites. No CR origination date restriction was placed on the search. The search included IP2 and IP3. CR descriptions were searched for the words “buried” or “underground.” The searches resulted in 89 hits that were related to CAT “A” or CAT “B” CRs. In addition, 11 CAT “C” hits in HQN, NOE and LAR CRs were reviewed. The causes and corrective actions from pertinent CRs in the search results were considered during this root cause evaluation. Attachment V contains a list of the pertinent Entergy CRs.

A search was also performed for all IPEC CAT “C” CRs that contained the words “buried” or “underground.” The search returned 100 hits. The CRs were reviewed and one CR of note was CR IP3-2007-01852. The CR documented a steam leak on an 8” auxiliary steam line. This past event was determined to not be similar in that the issue was the original coating of the steam line being incorrect for the application. See additional information regarding this leak below.

Unit 1 to Unit 3 Aux Steam Buried Pipe Leak – On April 7, 2007, CR IP3-2007-01852 was initiated stating, “There are large underground steam leaks just west and north of the U3 ETA tank moat. Two separate leaks exist, one on the north corner of the moat and the other about 10’ west of the moat. The pavement around these leaks is very soft and may impede transformer replacement/work if heavy equipment is needed to travel over this area.

Work Order IP3-07-19295, was written requesting excavation of the material surrounding the 8” Aux Steam line leaks. Further actions shall be taken as a function of the results of the visual inspection of the leak areas. Work Order IP3-07-19911, was written to perform the necessary repair of the steam line.

The 8” Ø Aux Steam line has a minimum of 9” thick gilsosherm insulation over which a 1’6” thick soil cover is provided. The Aux Steam and the 4” Ø Condensate line have special supports which are located every 15’. Details of the supports are as follows:

# Previous Occurrence Evaluation

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## External

A search of external operating experience data was performed for this event using the INPO web. The searches were conducted but not limited to SOERs, SERs, SENs, Topical Reports, NRC GLs, NRC INs, NRC Bulletins, Plant Events, LERs, EPIX, NPRDs and vendor notifications. A date restriction was not placed on the searches. Searches consisted of OE containing “buried: and “pipe” of which 247 hits were returned. Twelve pertinent CRs from the OE search were noted for which the information provided was considered in this root cause evaluation. A summary of the pertinent OE is contained in Attachment VI.

# Safety Significance Evaluation

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There is no safety significance to the operating plant as a direct result of the degraded condition on the 8" CST return line based on the following:

1. Overall integrity of the subject line was evaluated under Calculation IP-CALC-09-00032 (EC 13322) to be structurally adequate per ASME CC-N513-2 with the through wall leak and the subject line remained operable.
2. Presence of the through wall leak can drain the 8" Condensate return but it will not siphon the CST. Since the CST overflow line enters/exits the CST at the same elevation as the 8" return line, (i.e. 115'5" pipe centerline (Drawing 9321-F-2264)) and the 8" return line is equipped with a 3/4" siphon breaker hole drilled at the top of the pipe inside the tank (9-9237-DWG-19), the volume loss in the CST is effectively limited to the volume of water present in the return and overflow lines. This siphon breaker ensures that the CST water level remains at a minimum of 34.01' from the tank bottom which in turn ensures approximately 645,000 gallons (Graph TC-6, Rev 1 and Calculation FIX-00024) is maintained in the tank.
3. The loss in inventory returned back to the CST, with the AFW pumps in operation re-circulating to the CST through a postulated degradation is estimated to be less than 15 GPM. This estimate is conservative since the increase in pressure at the area from pump operation is expected to be less than 1 psig. (Normal head pressure from the CST is about 40 psig. Estimated differential pressure drop through 300' of 8" schedule 40 pipe at a flow rate of 650 gpm is less than 1 psid from the Appendix B Table B-14 of Crane Technical Paper 410). The increase of 1 psid over the initial 40 psid is about 1% in flow. Based on the pump out rate of approximately 10-12 gpm noted during uncovering of the subject pipe, the estimated increase is expected to be significantly less than 15 gpm stated. Assume a 15 gpm loss of inventory through the breach, the estimated volume loss from the CST for a 24-hour period would be about 21,600 gallons (1.13' in tank level).
4. In support of decay heat removal, Technical Specification (TS) 3.7.6 requires a minimum of CST volume of 360,000 gallons for 24 hours following a trip at 100.6% rate thermal power (RTP). Due to piping degradation, some of the recirculation flow from operating AFW Pump would be lost and additional volume in the CST is required for this for 24 hours. Based on the condition which existed, CST volume would have to be increased by approximately 21,600 gallons to accommodate inventory loss through the breach above the 360,000 gallons resulting in a required volume of 381,600 gallons. Rounding this to 400,000 gallons, it is equivalent to an approximately indicating level of 17'. A review of IP2 CST trend since 1/1/2007 to the present, minimum indicated CST level is above 19'. Additionally, multiple barriers are in place to support CST inventory about the 17' indicating level. These barriers include a low-level alarm at 19.5' and 19.2', and automatic closure of LCV-1158 at 18.21'.
5. There is no significant environmental impact since the leakage is discharged via the site storm drainage system because the CST is already identified in the IPEC SPEDES Permit. Leakage was directed to the nearby storm drainage (e.g. Manhole #5). Environmental Engineering was informed of the condition and has been monitoring these discharges. It was noted that a minute level of Tritium was detected in the samples.
6. There is no industrial impact as a result of the degradation. The leakage was underground below the concrete flooring. Subsequent excavation and repair to the subject pipe was conducted in accordance with the accepted work practice.
7. City water is available as a backup to the CST in the event that the CST level drops below the level required to perform its safety function.

# Safety Significance Evaluation

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In summary, there is no safety significance to the health and safety of the public from nuclear, safety, industrial or environmental associated with the subject event due to the condition of the degraded 8" CST return line. Multiple barriers are in place to insure the minimum required CST inventory is not challenged as a direct result of the piping degradation and any discharge is monitored consistent with the SPEDES Permit.

# Corrective Action Plan

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**A. Immediate Actions: {Describe actions performed on discovery and remedial actions which were taken to mitigate the consequences of the event or condition}**

1. Replaced the damaged section of the 8” CST return piping per Work Order 00183296.
2. Released to the industry as OE28335; (Preliminary) Leaking Underground Condensate Return Line Pipe. (IPEC, IP2) Consequently, this will be reviewed by each site as it enters the OE screening process from INPO. (CA-06 of this CR.)

**B. Interim Actions (if required): {Document any interim actions needed to minimize the likelihood of recurrence WHILE THE LONG-TERM ACTIONS ARE COMPLETED. Each interim action should only last until a specific long-term action is completed.}**

1. Send out the failed section of pipe for failure analysis. **Assign to P&C Eng, Due Complete**
2. Track failure analysis for the failed section of the pipe and document the results of the testing and analysis. **Assign to P&C Eng, Due 5/21/2009**
3. Discuss this Root Cause Analysis with the ESP population, through ESP Continuing Training “Kick-Off” session. **Assign to P&C Eng, Due 10/15/2009**
4. Review modification and corrective maintenance packages ready for installation that are related to buried piping and backfilling. **Assign to Design Eng, Due 6/25/2009**

# Corrective Action Plan

**Long Term Actions:** {DESCRIBE recommended actions to mitigate consequences and prevent recurrence. IDENTIFY which actions are Corrective Actions to Prevent Recurrence (CAPRs) and any which are Long-Term CAs per EN-LI-102.

Identified Causes	Corrective Actions	Resp. Dept.	Due Date
RC <sub>1</sub> , CAPR and CC <sub>1</sub> .	Update the buried piping backfill and excavation specification for IPEC as a site.	Design Eng	12/17/2009
CC <sub>2</sub>	Implement improved inspection techniques for buried piping.	P&C Eng	9/10/2009
DC	Send out removed pipe for failure analysis. Track and evaluate results	P&C Eng	5/21/2009
RC <sub>1</sub>	Research the original construction of this buried pipe for any additional backfill guidance that may have been available	Design Eng	9/24/2009
CC <sub>1</sub>	Evaluate the need/feasibility for cathodic protection to be used on selected buried piping. Initiate Engineering changes and present to the URT with results, as necessary.	P&C Eng	12/17/2009
CC <sub>1</sub>	Evaluate the need for a drainage system and monitoring for CST lines, near Manhole #5. Initiate Engineering Changes and present to the URT, as necessary.	Design Eng	12/17/2009
CC <sub>2</sub>	Ensure inspection locations are based on risk. Considering highly moist environments to be included in the procedure. Include Corporate Engineering Programs (CEP) for inspection guidance.	Eng - HQN	6/15/2009
CC <sub>2</sub>	Evaluate the need to add cathodic protection to those areas of buried pipe whose inspections have indicated pipe defects.	P&C Eng	11/15/2009
EOC	Once additional inspections are complete, initiate additional CAs as required and present the results to CARB.	P&C Eng	9/24/2009
Other	Evaluate the use of existing monitoring wells for buried pipe and tank leaks as early leak detection. Update monitoring wells testing requirements as necessary.	Projects	7/23/2009
OE	Issue an internal fleet-learning NOE in accordance with EN-LI-102 Attachment 9.5 to [fleet manager identified by CARB] to evaluate this for the fleet ” (Preliminary)	OE Coordinator	Complete
OE	Issue/revise an internal/external OE to the Industry for this Root Cause Evaluation in accordance with EN-OE-100	OE Coordinator	6/18/2009

# Corrective Action Plan

Identified Causes	Corrective Actions	Resp. Dept.	Due Date
EOC	Perform pipe inspection at the location; IP2 8" Condensate Return Line in the excavated area in the FRV Room"	P&C Eng	9/10/2009
EOC	Perform pipe inspection at the location; IP2 12" Condensate Supply Line in the excavated area in the FRV Room"	P&C Eng	9/10/2009
EOC	Perform pipe inspection at the location; IP2 24" SW Line 408 in the Transformer Yard outside the PAB where it exits the ground"	P&C Eng	9/10/2009
EOC	Perform pipe inspection at the location; IP3 12" Condensate Supply Line outside the Auxiliary Feedwater Pump Building where it goes underground.	P&C Eng	9/10/2009
EOC	Perform pipe inspection at the location; IP3 8" Condensate Return Line outside the Auxiliary Feedwater Pump Building where it exits the ground.	P&C Eng	9/10/2009
EOC	Perform pipe inspection at the location; IP3 24" Line 408 in the backup pump valve pit	P&C Eng	9/10/2009
Effectiveness Review	Issue an LOCA to track and document the RCA effectiveness review	CA&A	5/28/2009

# Effectiveness Review Plan

**Effectiveness reviews are required for all CAPRs ( and may also encompass the entire corrective action plan). This section should contain an Effectiveness Review strategy that includes the following:**

- ***METHOD** – describe the method that will be used to verify that the actions taken had the desired outcome.*
- ***ATTRIBUTES** – Describe the process attributes to be monitored or evaluated.*
- ***SUCCESS** – Establish the acceptance criteria for the attributes to be monitored or evaluated.*
- ***TIMELINESS** – Define the optimum time to perform the effectiveness review.}*

**THE FOLLOWING DEFINES THE EFFECTIVENESS REVIEW PLAN FOR THE CAPRS IN THIS CORRECTIVE ACTION PLAN:**

CAPR		<b><u>(State the CAPR(s) here)</u></b>	<b>Resp. Dept.</b>	<b>Due Date</b>
		1. Design Engineering to update the buried piping backfill and excavation specification for IPEC as a site.		
	Method	1. Document review of the new specification issued for IPEC.	P&C Eng	
	Attributes	1. Verify new specification thoroughly addresses: Details of gravel, sand rock size Layering requirements, dimensions Type of fill	Design Eng	
	Success	1. The details specified in Attributes section have been adhered to.	Design Eng	
	Timeliness	1. Perform a review 3 months after completion of the CAPR (Nine months has been allowed to complete the specification).	P&C Eng	
		<b>See Att. 9.10 in LI-118 (REPEAT SEQUENCE ABOVE FOR EACH CAPR)</b>		

# References

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## Documents reviewed:

1. EN-LI-118, Root Cause Analysis Process
2. EN-DC-343, Buried Piping and Tank Inspection and Monitoring Program
3. EN-LI-119, Apparent Cause Evaluation (ACE) Process
4. Corrosion and Cathodic Protection Theory, Bushman and Associates, Inc.
5. Siebert, CA and Bush, SH - Literature Survey on Underground Pipe Lines, Their Corrosion and Protection. Engineering Research Institute, University of Michigan
6. Jonas, O. (PE; PhD) - Water Chemistry and Corrosion Control, Training Course Material
7. LO-IP3LO-2008-00151, CA 19, Attachment 1, IPEC Buried Piping Impact Assessment, Corrosion Risk Ranking and Inspection Prioritization Methodology
8. IP-RPT-09-00011, EC 13500, Corrosion/Cathodic Protection Field Survey of Underground Structures at IPEC during October 2008
9. Watson, TRB - Why Metals Corrode
10. EPRI Report 1016456, Draft 3, September 2008 – Recommendations for an Effective Program to Control the Degradation of Buried Pipe
11. IP Drawing 9321-F-2019 – Flow Diagram Boiler Feedwater
12. IP Drawing 9321-2018 – Flow Diagram Condensate and Boiler Feed Pump Suction
13. IP Drawing 9321-F-1024 – Containment Building Backfilling and Grading North and East Side
14. IP Drawing 9321-F-1209 – Shield Wall Area Concrete Foundation Sections
15. Drawing 9321-F-1002 – Plot Plan – UFSAR Figure No 1.2-3
16. Drawing 9321-F-1208 – Shield Wall Area Concrete Plan Elevation 18'6"
17. Drawing 9321-F-1231 – Shield Wall Elevations and Section – Sheet No 2
18. Drawing 9321-F-2263 – Yard Area – Condensate Storage Tank to Turbine Building Condensate Piping Plan – Sheet No 1
19. Drawing 9321-F-2264 – Yard Area – Condensate Storage Tank to Turbine Building Condensate Piping Plan – Sheet No 2
20. Structural Integrity Associates Inc, Report No. 0900235.401

# References

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## Personnel contacted:

1. Greg Bouderau
2. Joe Peterson
3. Joe Ruch
4. Bob Allen
5. Bob Danko – Stone and Webster
6. Rich Meyer Jr – Stone and Webster
7. John Bouse – Stone and Webster
8. Michael O’Brien – Stone and Webster
9. Charles Kiall – Stone and Webster
10. Robert Okuniewski – Stone and Webster
11. Tom Camilliere – Stone and Webster
12. Bernard Barreiro – Stone and Webster
13. John Curry
14. Charlie Jackson
15. Bob Eifler
16. Kai Lo
17. Jan Mayer
18. Kevin Curley
19. Mike Tesoriero
20. Nelson Azevedo
21. Bob Lee
22. Matt Barvenik – GZA Geo Environmental Incorporated

# References

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**Analysis Methodologies employed:** *{List all analysis methods used}*

1. Why Analysis
2. K-T Method
3. SIA Report “Analysis of 8” Condensate Water Storage Tank Return Line CD-183”, Report No. 0900235.402

**Attachments:** *in PCRS*

- I. Equipment Failure Evaluation
- II. K-T Analysis
- III. Why Staircase
- IV. Operating Experience