UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 15, 2016

Vice President, Operations
Entergy Nuclear Operations, Inc.
Indian Point Energy Center
450 Broadway, GSB
P.O. Box 249
Buchanan, NY 10511-0249

SUBJECT: SERVICE WATER AND FIRE WATER SYSTEMS AGING MANAGEMENT PROGRAMS AUDIT REPORT FOR THE INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3 LICENSE RENEWAL APPLICATION (CAC NOS. MD5407 AND MD5408)

Dear Sir or Madam:

By letter dated April 23, 2007, as supplemented by letters dated May 3, 2007, and June 21, 2007, Entergy Nuclear Operations, Inc. (Entergy), submitted an application pursuant to Title 10 of the *Code of Federal Regulations* Part 54, to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3.

The NRC staff conducted a supplemental regulatory audit onsite from February 23-25, 2016, to gain a better understanding of Entergy's responses to the requests for additional information submitted by letters dated December 16, 2014, and August 18, 2015 (ADAMS Accession Nos. ML14365A069 and ML15236A017, respectively) related to LR-ISG-2012-02, "Aging Management of Internal Surfaces, Fire Water Systems, Atmospheric Storage Tanks, and Corrosion Under Insulation." The audit report is enclosed.

If you have any questions, please contact me by telephone at 301-415-6459, or by e-mail at michael.wentzel@nrc.gov.

Sincerely,

/RA/

Michael J. Wentzel, Project Manager
Environmental Review and Projects Branch
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-247 and 50-286

Enclosure:
As stated

cc: Listserv

Vice President, Operations
Entergy Nuclear Operations, Inc. June 15, 2016
Indian Point Energy Center
450 Broadway, GSB
P.O. Box 249
Buchanan, NY 10511-0249

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Letter to Vice President, Operations, Entergy from M. Wentzel dated June 15, 2016

SUBJECT: SERVICE WATER AND FIRE WATER SYSTEMS AGING MANAGEMENT PROGRAMS AUDIT REPORT FOR THE INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3 LICENSE RENEWAL APPLICATION (CAC NOS. MD5407 AND MD5408)

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U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION, DIVISION OF LICENSE RENEWAL

Docket Nos.:	50-247, 50-286
License Nos.:	DPR-26, DPR-64
Licensee:	Entergy Nuclear Operations, Inc.
Facility:	Indian Point Nuclear Generating Unit Nos. 2 and 3
Location:	450 Broadway, GSB Buchanan, NY 10511-0249
Dates:	February 23 – 25, 2016
Reviewers:	M. Wentzel, Project Manager, Audit Team Leader, Division of License Renewal (DLR) W. Holston, Sr. Mechanical Engineer, DLR J. Gavula, Mechanical Engineer, DLR B. Allik, Materials Engineer, DLR
Approved By:	Dennis Morey, Chief Aging Management of Reactor Systems Branch Division of License Renewal Yoira Diaz-Sanabria, Chief Projects Branch 1 Division of License Renewal

ENCLOSURE

1. Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit at Indian Point Nuclear Generating Units Nos 2 and 3 (IP2 and IP3) from February 23-25, 2016. The purpose of the audit was to gain a better understanding of Entergy Nuclear Operations, Inc.'s (Entergy's) responses to the requests for additional information (RAIs) submitted by letters dated December 16, 2014, and August 18, 2015 (ADAMS Accession Nos. ML14365A069 and ML15236A017, respectively) related to LR-ISG-2012-02, "Aging Management of Internal Surfaces, Fire Water Systems, Atmospheric Storage Tanks, and Corrosion Under Insulation."

The regulatory bases for the audit were the requirements in Title 10 of the *Code of Federal Regulations* (CFR) Part 54 (10 CFR Part 54), "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." Guidance is provided in NUREG-1800, Rev. 2, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants" (SRP-LR), NUREG-1801, Rev. 2, "Generic Aging Lessons Learned (GALL) Report," and LR-ISG-2012-02.

During the audit, the NRC staff reviewed the Entergy's Service Water Integrity Program and Fire Water System Program, operating experience, site implementing procedures, other relevant documents, and related references; interviewed various Entergy representatives; and conducted breakout sessions on several issues related to the Service Water Integrity Program and Fire Water System Program.

A more detailed discussion follows.

2. Review of the Fire Water System Program

Audit Activities. During this supplemental audit of the Fire Water System Program, the NRC staff interviewed Entergy's onsite and contractor staff, and reviewed site documentation provided by Entergy. The NRC staff conducted an independent search of Entergy's operating experience database to assess past leakage in the fire water and city water systems as it relates to recurring internal corrosion. The NRC staff also reviewed site documentation related to the fire water system deluge valve testing and internal inspections of wet sprinkler piping. The table below lists the documents that were reviewed by the NRC staff and found to be relevant to the audit.

Relevant Documents Reviewed

Document	Title/Description	Revision/Date
04UT044	Straight section of pipe – 5 feet north of FP-2	July 26, 2004
050000247/2003011	Indian Point Nuclear Generating Unit 2 – NRC Integrated Inspection Report	November 10, 2003
05000247/2015001 and 05000286/2015001	Indian Point Nuclear Generating – NRC Integrated Inspection Report	May 12, 2015
227551-0	Fire Protection System Drawing Details Sheet 1[IP2]	Revision 0

Document	Title/Description	Revision/Date
2-PT-2Y006	PAB Charcoal Filter Deluge Systems Surveillance	Revision 9
2-PT-2Y006	PAB Charcoal Filter Deluge Systems	Revision 9
2-PT-2Y006	Results of Surveillance Tests - PAB Charcoal Filter Deluge Systems	October 1, 2007 October 1, 2009 July 1, 2011 November 1, 2013 January 1, 2016
A227551-66	Fire Protection System Diagram Details Sheet 1; Detail “E,” Charcoal Filter Deluge System	December 24, 1987
AR 161941	10Y [year] Perform UTs [ultrasonic testing] on FP Piping [This document reflects an addition of a new preventive maintenance activity]	No date or revision
CR-IP2-200305642 CR-IP2-200305672	Apparent Cause Evaluation - Leak in the IP1 Fire Protection Header	October 2, 2003
CR-IP2-2007-0462	Two drops per second leak coming from an elbow in a city water line in the overhead of the 15 foot elevation of the turbine hall	January 26, 2007
CR-IP2-2007-3810	Two small leaks on a FP pipe up stream FP 1363 located on 15 foot elevation north west loading door. The leak rate is approximately one drop every 10-20 minutes	September 22, 2007
CR-IP2-2008-0044	Pinhole leak in a 10" FP line, approximately 2 feet south of an existing patch on this FP line	January 4, 2008
CR-IP2-2008-3379	Through wall leak in fire header piping section between FP-60 and fire pump room in overhead section of maintenance area of Unit 1. [Ultrasonic inspection conducted with satisfactory results]	July 15, 2008
CR-IP2-2008-3396	Through wall pipe leak on a 6-inch diameter FP pipe near valve FP-39. The leak rate is approximately one drop per minute. [Ultrasonic inspection conducted with satisfactory results]	July 16, 2008
CR-IP2-2009-1089	Piping upstream of UW-364 is leaking 40 drops per minute.	March 26, 2009
CR-IP2-2009-1432	The spool piece between FP-63 and FP-64 on the deluge line in 11 fire main booster pump room, has a through wall pin-hole leak. [Ultrasonic inspection conducted with satisfactory results]	April 25, 2009

Document	Title/Description	Revision/Date
CR-IP2-2009-1457	Corrosion on the underside of a six-inch elbow adjacent to FP-240, with evidence of past leakage and some moisture present at the corrosion site. No active leakage was observed. [Ultrasonic inspection conducted with satisfactory results]	April 27, 2009
CR-IP2-2009-1764	City water pipe leak downstream of MW-926.	May 16, 2009
CR-IP2-2009-1961	A previously patched hole on the fire header piping in stairway 6 near FP-173 started leaking/spraying.	May 27, 2009
CR-IP2-2009-3451	City water piping upstream of MW-875 and MW-746 has a through wall leak of approximately 100 milliliters per minute.	September 1, 2009
CR-IP2-2009-4269	Small through-wall leak of one drop per 20 minutes on second weld of pipe reducer just upstream of FP-863.	October 17, 2009
CR-IP2-2010-2171	There is a pinhole leak spraying out a mist of water located in the vertical run of piping about 1 and one-half feet above the tee for FP-174. [Ultrasonic inspection conducted with satisfactory results]	March 27, 2010
CR-IP2-2010-3293	Two and one-half inch city water line in the 28 foot elevation locker room, unit 1, appears to have a through-wall leak. Leak rate is about one quart a day.	May 26, 2010
CR-IP2-2010-4000	A pinhole leak was observed on FP line upstream of FP-88 (Supply to U2 standpipe west). The physical location of the leak appears to be on the bottom of the pipe. Leak rate is minor with one drop per minute. [Ultrasonic inspection conducted with satisfactory results]	June 12, 2010
CR-IP2-2010-4606	A small pinhole leak was discovered on a three-inch pipe to a reducer weld one foot upstream of valve FP-863. The leak is approximately one drop in 5 or 10 minutes. [Ultrasonic inspection conducted with satisfactory results]	July 15, 2010

Document	Title/Description	Revision/Date
CR-IP2-2010-5187	While checking a 10-inch FP pipe for WO 135106, another pinhole leak was found 6 inches from a leak south of FP-2, which was identified in 2008, and 12 inches from a leak identified in 2004. The leak is about one drop ever 10 seconds. [Ultrasonic inspection conducted with satisfactory results]	August 18, 2010
CR-IP2-2010-5612	FP line appears to have a leak. The line is insulated and the leak is directly over the small scrap metal container located on the 15 foot elevation in the Unit 1 turbine building south west loading bay near the weld shop.	September 8, 2010
CR-IP2-2010-799	There is a pinhole leak downstream of FP-36 on the elbow leading to the fire main header. It is near the downstream flange at the nine o'clock position. There is a large pit in the pipe where the leak is originating at. It is leaking approximately one drop every 5 minutes. [Ultrasonic inspection conducted with satisfactory results]	February 15, 2010
CR-IP2-2011-1978	There is a through-wall leak downstream of FP-37, originating where the pipe goes through the floor of the 33-foot elevation. The leak rate is less than one drop per minute. WRN 234551. [Ultrasonic inspection conducted with satisfactory results]	April 23, 2011
CR-IP2-2011-1980	There is a through-wall leak on the FP piping 15-foot elevation, unit 1, 10 feet west of FP-4. [Ultrasonic inspection conducted with satisfactory results]	April 23, 2011
CR-IP2-2011-2058	A new leak was found about 6 feet down from another leak. It has a drop formed but is not actively leaking. [Ultrasonic inspection conducted with satisfactory results]	April 27, 2011
CR-IP2-2011-2806	As a result of an extent of condition walk down performed under CR-IP2-1980, 15 additional leaks were found on the 10-inch FP pipe in Unit 1 and 3 leaks in Unit 2 10-inch pipe.	June 8, 2011
CR-IP2-2011-3777	Through-wall leak on piping in city water meter house. Located upstream of UW-269 at weld connection to header.	July 29, 2011

Document	Title/Description	Revision/Date
CR-IP2-2011-3785	Leak at weld between piping and UW-382 just upstream of valve. Leak rate is less than one drop per minute.	July 30, 2011
CR-IP2-2011-4529	The main fire header has an apparent two to three drop per minute leak under the lagging somewhere between UW-335 and FP-217. Water is dripping out of a seam in the lagging and there is no visible water dripping on the pipe from above.	September 10, 2011
CR-IP2-2011-5326	A significant city water leak of approximately 2 to 3 gallons per minute was discovered coming from a city water line on 33 foot elevation in the NSB. The leak is between valves UW-30 and UW-71.	October 25, 2011
CR-IP2-2011-5686	During a walkdown of Unit 115-foot elevation FP piping, three separate leaks were found on a section of 10-inch diameter piping, located in the overhead next to the west wall of the maintenance area bounded by the valves FP-39 and FP-60. The leak rate of each location is approximately 5 drops per minute.	November 9, 2011
CR-IP2-2011-5889	There are three pinhole through-wall pipe leaks in the same piping approximately 12 inches apart. They are located down stream of valve UW-507. The leakage is less than 1 drop per minute between the three. [Ultrasonic inspection conducted with satisfactory results]	November 20, 2011
CR-IP2-2011-6310	The tee downstream of check valve UW-607 has a through-wall leak which is leaking approximately 10 drops per minute.	December 10, 2011
CR-IP2-2012-2275	There is small pinhole leak about 1/8 inch in diameter on the pipe down stream of FP-1 at the 1 o'clock position. [Ultrasonic inspection conducted with satisfactory results]	March 24, 2012
CR-IP2-2012-3342	The pinhole piping leak that was identified between FP-1and the wall penetration in CR No. 2275, appears to be getting worse. The pressure of the water is channeling its way through the temporary patch, causing water to spray into the wall penetration.	May 13, 2012

Document	Title/Description	Revision/Date
CR-IP2-2012-7019	During pump testing, a leak was discovered on the FP system coming from the third elbow upstream of valve FP-822. The leak was reported as being a steady stream of water at least 4 to 5 gallons per minute.	December 1, 2012
CR-IP2-2013-0076	There is a pinhole leak in the piping downstream of FP-75. While attempting to cycle the valve, the leak was spraying out excessively and prevented valve from being fully cycled.	January 6, 2013
CR-IP2-2013-1634	During a fire protection system walkdown, valve FP-30, was noted to have a through-wall weeping leak in the valve body. Leakage is very slight but enough to wet the outside of the valve body.	May 2, 2013
CR-IP2-2013-1779	Seven new pinhole leaks were identified in the section of 10-inch diameter pipe west of FP-3. This pipe section had one pinhole leak previously identified under CR-IP2-2011-2806.	May 6, 2013
CR-IP2-2014-2482	A three-quarter inch elbow upstream of FP-105 is badly corroded and leaking at a rate of 8 ounces per minute. Elbow to pipe connection appears very fragile and close to a complete break.	April 13, 2014
CR-IP2-2014-2554	There are three through-wall leaks at the bottom of the pipe on the Unit 1 FP header estimated at about five drops per minute.	April 8, 2014
CR-IP2-2014-2732	A four-inch tee connection on the fire header in Unit 2 fuel storage building has an approximately 30 drops per minute leak.	April 18, 2014
CR-IP2-2014-3445	There is an approximately 2 gallons per minute leak from the city water system, just above FP-9. CR-IP2-2015-4927, dated 11/02/2015, documented that this leak rate worsened.	June 9, 2014
CR-IP2-2015-0224	A pinhole piping leak has been identified on the line exiting FP-1 (after wall penetration from the 12 Fire Main Booster Pump Room). Previously, a leak had been identified on the inside of the room between FP-1and the wall penetration. [Ultrasonic inspection conducted with satisfactory results]	January 15, 2015

Document	Title/Description	Revision/Date
CR-IP2-2015-0285	There are 5 small through wall leaks on a 10-foot section of the fire header above 12 house service boiler feed pump, leaking approximately 1 to 3 drops per minute each.	January 20, 2015
CR-IP2-2015-1543	There is a small active leak, approximately 30 drops per minute, and a continuous fine mist leak on the weld of the piping downstream of valve UW-507.	April 12, 2015
CR-IP2-2015-2098	The piping is rusted and there is evidence of a through-wall leak upstream of MW-714.	May 13, 2015
CR-IP2-2015-3464	A pinhole leak was identified at a nipple on the north manway of the city water storage tank. The leak rate is approximately 0.5 gallons per minute.	August 6, 2015
CR-IP2-2015-3503	A through-wall leak developed upstream of FP-717. CR-IP2-2015-3862, dated 08/27/2015, stated that the house-keeping patch was leaking approximately 20 drops per minute.	August 10, 2015
CR-IP2-2015-3768	There is a fire header through-wall leak located south of valve FP-14, estimated at 34 drops per minute. Leak looks to be coming from an area that was previously repaired. [Ultrasonic inspection conducted with satisfactory results]	August 22, 2015
CR-IP2-2015-4986	A small through wall leak was identified on a fire protection line near valve FP-13. The leak rate is approximately 1 drop per minute.	November 4, 2015
CR-IP3-2010-02516	Through wall leakage noted on inlet piping to FP-MOV-1718 (FWST 2 NATURAL CIRC. AUTO CONTROL VALVE). Leakage is minor (approximately one drop in 5 minutes).	August 22, 2010
CR-IP3-2011-1525	A close-up inspection of the city water pipe revealed the presence of two temporary leak repair patches, held in place with hose clamps. At the wall penetration the repair patch is leaking 2 drops per second. The second repair patch is on the second elbow just downstream of the wall penetration. In this area of concern, the pipe is heavily corroded with obvious signs of wall loss for a total length of 2 feet.	March 21, 2011
CR-IP3-2011-4490	Operations identified a small pinhole leak in the two-inch bypass line around valve FP-46.	September 28, 2011

Document	Title/Description	Revision/Date
CR-IP3-2012-2858	A through-wall leak was found on the bypass line around a fire pump test header isolation valve. It is spraying onto the diesel fire pump.	September 14, 2012
CR-IP3-2012-3789	There is a pinhole weld leak on the fire water storage tank heaters and circulating water pumps suction piping. The leak is approximately 20 drops per minute.	November 29, 2012
CR-IP3-2012-3790	There is a pinhole leak on a spot-weld right as the fire water storage tank cross-connect valve reaches the "T" that splits to the suction piping of fire water storage tank circulating water pumps 2A and 2B. The leak is approx. 20 drops per minute.	November 29, 2012
CR-IP3-2013-4816	The elbow downstream of FP-271 has a through wall leak.	December 12, 2013
CR-IP3-2014-0960	The elbow downstream of FP-271 has a through wall leak.	May 5, 2014
CR-IP3-2015-3734	There are three through-wall leaks on the inlet piping to FP-MOV-1718. The leakage is minor, but small stalactite-like forms are developing.	July 2, 2015
IP2-UT-008-02	10” Line D/S [downstream] valve FP-2	January 11, 2008
IP2-UT-11-051	UT Erosion/Corrosion Examination – 10” Fire Protection Line Downstream of Valve UW-507	December 8, 2011
IP2-UT-11-052	UT Erosion/Corrosion Examination – 10” Fire Protection Line Downstream of Valve UW-507	December 8, 2011
IP2-UT-11-053	UT Erosion/Corrosion Examination – 10” Fire Protection Line Downstream of Valve UW-507	December 8, 2011
IP-CALC-08-00102	Evaluation of Leaks for Fire Protection Piping at FP-39 and FP-61	July 22, 2008
IP-CALC-12-00077	Minimum Wall Thickness of Fire Protection Piping Inside Utility Tunnel	July 26, 2012
IP-CALC-12-00081	Minimum Wall Thickness of Fire Protection Piping	August 23, 2012
IP-RPT-12-LRD02	Engineering Report IP2 Fire Water Piping Wall Thickness Evaluation for IP2 License Renewal	May 22, 2013
LRA-9321-4006	Flow Diagram of Plant Fire Protection System Sheet 1 [IP2]	Revision 0
LRA-9321-40903	Flow Diagram of Plant Fire Protection System Sheet 1 [IP3]	Revision 29

Document	Title/Description	Revision/Date
LRA-9321-40913	Flow Diagram of Plant Fire Protection System Sheet 2 [IP3]	Revision 25
NL-07-138	Reply to Request for Additional Information Regarding License Renewal Application	November 16, 2007
PMRQ 00031048	10Y PEO [period of extended operation] Fire Protection Piping UT Inspections	No date or revision
PT-EM15	Diesel Generator Building Water Sprinkler System	Revision 4

Based on its review of the documentation identified above and discussions with Entergy's onsite and contractor staff, the NRC staff notes the following:

Deluge valve testing:

During its evaluation of the response dated August 18, 2015, to RAI 3.0.3-9, the NRC staff concluded that it lacked sufficient information to establish reasonable assurance that deluge valve testing for the charcoal filter units would ensure that the intended function of the deluge system and associated charcoal filters would be met. In part, the response states "Fire water is distributed through a series of holes in the piping within the charcoal filter beds." NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," Section 13.4.3.2.2.5 (a) states that, "[w]here the nature of the protected property is such that water cannot be discharged, the nozzles or open sprinklers shall be inspected for correct orientation and the system tested with air to ensure that the nozzles are not obstructed." Typical air testing is conducted by injecting air into the deluge system piping and observing the flow of air from the deluge nozzles. This would not be possible with this plant-specific configuration because the nozzles/holes are within the charcoal filter beds. The NRC staff reviewed the applicant's test procedure for the deluge valves. The applicant's procedure directs the technician to pressurize the header with air, open the deluge valve, and confirm that the header depressurizes.

During its review of the deluge valve test procedure, the NRC staff noted that one step in the procedure directed the technician to estimate the quantity of water drained from the deluge system piping during test setup. Although at least portions of the piping are stainless steel, it was not clear to the NRC staff that all of the piping is stainless steel. If water collects in normally-dry steel piping, industry operating experience (see U.S. Nuclear Regulatory Commission Information Notice 2013-06, "Corrosion in Fire Protection Piping Due to Air and Water Interaction") has demonstrated that sufficient corrosion products can accumulate and result in significant flow blockage. The NRC staff reviewed the results of 10 years of surveillance results and the piping drawings. The surveillance results demonstrated that no moisture had accumulated in the piping. The drawings showed that a drain trap is installed on the piping. Based on the test results and piping configuration, the NRC staff concluded that there is reasonable assurance that the lines are normally dry.

Internal inspections of wet sprinkler piping:

In its letter dated December 16, 2014, Entergy stated that, if "there are multiple wet pipe systems in a structure, one third will be inspected every five years such that all systems will be inspected during each 15-year period." NFPA 25, Section 14.2 states that every other wet pipe

system should be inspected every 5 years. The NRC staff reviewed drawings, procedures, and the response to a scoping and screening RAI. Based on its review, the NRC staff concluded that the only buildings with more than two in-scope sprinkler systems were the diesel generator buildings. Where there are one or two sprinkler systems in a building, inspecting one-third of the systems results in at least one system being inspected. During each 15-year inspection period, six systems will be inspected (IP2 diesel fire pump building, IP2 diesel generator building, IP3 turbine building, IP3 fire pump house, IP3 auxiliary boiler feed pump room, and IP3 diesel generator building) in lieu of the eight systems that would be inspected if NFPA 25 guidance were followed. The NRC staff concluded that inspecting 6 systems every 5 years, with at least one test in each structure (e.g., IP2 diesel fire pump building, other buildings with only one wet pipe system) can provide reasonable assurance that debris is not accumulating in the wet pipe systems.

Recurring internal corrosion (RIC) in the fire water and city water systems:

By letter dated December 16, 2014, Entergy provided the following information:

- The Fire Water System Program includes volumetric wall thickness measurements to ensure that wall thickness is within the required structural limits. Entergy also stated that the wall thickness measurements conducted for IP2 prior to the end of its original operating term did not identify any unacceptable wall thinning. Entergy also stated that, "[l]ocalized corrosion has resulted in minor through-wall leaks that have no impact on system performance and do not threaten the structural integrity of the piping or the safety function of nearby equipment." Entergy did not propose any changes to its Fire Water System Program to address RIC.
- Loss of material in the city water system is managed by the Periodic Surveillance and Preventive Maintenance Program. Entergy stated that, "[h]owever, based on past operating experience, they [through-wall leaks] do not compromise the intended functions of these or any other system, and do not warrant aging management program activities beyond those provided by established aging management programs and the corrective action program." In its letter dated September 26, 2012, Entergy stated that visual inspection or other nondestructive examination (NDE) techniques will be used to inspect a representative sample of the internals of city water piping, and piping components to manage loss of material. Entergy did not propose any changes to its Periodic Surveillance and Preventive Maintenance Program to address RIC.

Despite Entergy's statement that minor through-wall leaks have had no impact on system performance, there have been at least two events where the system performance of the fire water system was impacted.

- Indian Point Nuclear Generating Unit 2 – NRC Integrated Inspection Report 050000247/2003011 documents a September 10, 2003, 80 gallons per minute leak that resulted in the fire water header not being available to perform its intended function for approximately 3 hours. The apparent cause for this leak states

> The apparent cause for the pin-hole leak is age related corrosion degradation of the piping, specifically, high-oxygenation pitting corrosion. The piping is original Unit 1 equipment, schedule 40 un-lined black steel pipe that is approximately 45 years old. The follow-up UT inspections indicated that the corrosion mechanism that resulted in the pinhole was

> not general pipe corrosion but was localized in the pinhole. The periodic testing of the system introduces fresh oxygen to the system and such cyclic re-oxygenation results in pits caused by 'high-oxygenation corrosion.' These pits then grow to become thru wall pinhole leaks in the piping. Portions not subject to periodic flow are not subject to this corrosion mechanism."

The cause evaluation did not provide an explanation as to why this pinhole leak, unlike numerous other pinhole leaks, resulted in a temporary loss of intended function of the fire water header.

- Indian Point Nuclear Generating – NRC Integrated Inspection Report 05000247/2015001 and 05000286/2015001 documents a December 29, 2014, failure of a 10-inch piping spool piece in the IP1 high pressure fire protection header that resulted in the fire water header not being available to perform its intended function for about 2 hours. The failure was as a result of a crack opening up along the longitudinal seam weld at the bottom of the pipe. Three previously identified pinhole leaks were located along the length of the cracked region. Entergy did not provide an apparent cause report for this failure.

The NRC staff plans to issue an RAI regarding the issue discussed below to ensure that it has been properly resolved.

The NRC staff reviewed a list of leaks in the fire water and city water systems provided by Entergy. These leaks encompassed those occurring from 2007 through 2015. During this time frame, there were approximately 42 leaks in the fire water system and 14 in the city water system. Sixteen of the fire water leaks were inspected using ultrasonic thickness techniques. Ultrasonic inspections were conducted on an additional 14 locations at IP2. Based on Entergy's evaluation of all of the thickness measurements, structural integrity requirements were met. The NRC staff reviewed Entergy's analytical techniques. Minimum wall thickness requirements were based on: (a) meeting hoop and longitudinal stress; (b) appropriate loadings, for example pressure, deadweight, and seismic when applicable; and (c) a conservative corrosion rate (i.e., as-measured wall thickness compared to nominal wall thickness plus 12-1/2 percent thickness). Entergy has generated a preventive maintenance activity to perform ultrasonic inspections at the additional 14 locations at IP2 by 2023. The NRC staff reviewed the ultrasonic thickness reports for two of the leaks associated with the December 29, 2014, failure. The NRC staff projected potential loss of material based on corrosion rates documented in Entergy's calculations. It would appear that structural integrity requirements would have been met on the day of the failure. Based on its review of these documents, the NRC staff concluded that conducting ultrasonic wall thickness examinations will not provide sufficient information to result in prevention of potential future losses of intended function of the fire water and city water system.

Lacking an apparent cause of the failure on December 29, 2014, and the limited causal analysis of the failure on September 10, 2003, the NRC staff has determined that it lacks sufficient information to conclude that Entergy has implemented effective means to provide reasonable assurance that future losses of intended function of the fire water and city water system will not occur.

3. Review of the Service Water Integrity Program

Audit Activities. During this supplemental audit of the Service Water Integrity Program, the NRC staff interviewed Entergy's onsite and contractor staff, and reviewed site documentation provided by Entergy. The NRC staff conducted an independent search of Entergy's operating experience database to assess past leakage in the service water system as it relates to recurring internal corrosion. The table below lists the documents that were reviewed by the NRC staff and found to be relevant to the audit.

Relevant Documents Reviewed

Document	Title/Description	Revision/Date
SEP-SW-IPC-001	Indian Point Energy Center [IPEC], NRC Generic Letter [GL] 89-13 Service Water [SW] Program.	12/10/2015
NA	IPEC System Health Report – Unit 2 Service Water System.	Q4 2015
NA	IPEC System Health Report – Unit 3 Service Water System.	Q4 2015
NA	IPEC GL 89-13 Program: All IP2 Components Detail Report.	Printed 02/22/2016
NA	IPEC GL 89-13 Program: All IP3 Components Detail Report.	Printed 02/22/2016
CR-IP3-2015-3789	Small leak on 3-inch service water line #1224 (SW supply from 4-5-6 to the CCR A/C [air conditioning] Units).	07/08/2015
CR-IP2-2015-5764	Leaking 2-inch socket welded elbow removed from #21 FCU [fan cooler unit] motor cooler for replacement under CR-IP2-2015-05755 has been tagged with nonconformance.	12/23/2015
CR-IP2-2015-5358	Small service water leak on 20-inch line #411(includes list of other operability evaluations in effect: CR-IP2-2015-00167, CR-IP2-2015-03550, CR-IP2-2015-04170).	11/30/2015
CR-IP2-2015-4351	Small leak on non-essential service water on both welds of 3rd 90-degree elbow upstream of SWT-659	09/24/2015
CR-IP2-2015-4239	Identified recent increase in number of through-wall leaks in Class 3 service water piping. CR was written to evaluate trend and listed: CR-IP2-2015-00167, CR-IP2-2015-3500, CR-IP2-2015-3550, CR-IP2-2015-3850, CR-IP2-2015-04170, and CR-IP2-2015-3789.	09/17/2015
CR-IP2-2015-4170	Service water leak in the 480-volt room near the instrument air desiccant dryers.	09/14/2015

Document	Title/Description	Revision/Date
CR-IP2-2015-3550	Service water leak inside the vapor containment on the return line from the #24 fan cooler unit motor cooler. Per CR-IP2-2015-3744, leak is 2 gpm and Operations determined #24 FCU was inoperable from time of discovery on 8/11. [Associated with LER 247/2015-001.]	08/11/2015
CR-IP2-2015-3500	R-49/46/53 have several through-wall leaks located in the Rad [radiation] Monitor house. Equipment listed as “Nonfunctional.”	08/09/2015
CR-IP2-2014-6504	Service water line downstream of SWN-940, supply to Rad Monitors R-49/46/53 has several through-wall leaks. Service water supply was isolated and Rad Monitors R-49/46/53 remain “Nonfunctional.”	12/17/2014
CR-IP2-2014-1179	Service water sample and purge lines to R-49, R-53, and R-46 have been leaking over the past several days. Equipment listed as “Nonfunctional.”	2/27/2014
CR-IP2-2013-5053	Thru-wall leak downstream of SWN-60 (SW to R-46, 49, and 53) and upstream of SWN-61. Equipment listed as “Inoperable.”	12/15/2013
CR-IP2-2013-3759	Eight pin-hole leaks in 2-inch service water piping for U2 Rad Monitoring System in the SW pipe chase. All locations are ISI [inservice inspection] Class 3 and ASME Code rules apply. CR-IP2-2008-04268 identified similar leaks on this piping. [Associated with LER 247/2013-004]	09/11/2013
CR-IP2-2013-1252	Piping upstream of SWN-851 leaks excessively, solid stream of water approximately 1 gpm.	04/03/2013
CR-IP2-2013-0115	Weld leak on 6-inch SG [steam generator] blow down drain line #390 where it connects to the 18-inch FCU service water discharge line #406.	01/09/2013
CR-IP2-2012-5002	SWT-818 service water supply to HPFW sentry cooler has a thru-wall leak. Found 15-foot SWAP area flooded. Secured HPFW supply to cooler and service water supply to SWT-818.	08/04/2012
CR-IP2-2012-4837	Small pinhole leak in service water downsteam of SWN-43-2 and SWN-43-5 (22 FCU drain stop and 25 FCU supply drain stop.	07/26/2012
CR-IP2-2012-4642	Two steady stream pinhole service water leaks downstream of SWN-42-5.	07/18/2012

Document	Title/Description	Revision/Date
CR-IP2-2012-1080	Volumetric (RT [radiographic testing]) inspections of welds 302740-W3 and 302740-W4 in service water line #11-SWN-SS found both welds degraded. 302740-W3 was found to have a through-wall crack. 302740-W4 was found completely oxidized with estimated remaining life of 3 years. Both welds appear to be fabricated from thinner Schedule 10S piping in lieu of Schedule 40S per piping spec. Non-ISI non-Code piping.	02/21/2012
CR-IP2-2012-0935	Volumetric (RT) inspections of welds 302740-W1 and 302740-W2 in service water system line #11-SWN-SS found multiple locations in welds and adjacent base metal for both that have significant wall thickness losses due to corrosion. Non-ISI, non-Code piping.	02/14/2012
CR-IP2-2012-0828	Volumetric (UT [ultrasonic testing]) inspections of weld S-2520 in service water system line 18-inch #405 found locations at the weld area that have wall thicknesses below the required 2-year service wall thickness in calculation IP-CALC-12-00010.	02/09/2012
CR-IP2-2010-6620	SWN-9-4, 25 SWP 14-inch discharge pipe vacuum breaker, base weld has pinhole leaks. This is on boundary side. Potential to flood pit in the event of catastrophic failure. This is an NRC finding.	10/29/2010
CR-IP2-2010-5442	During prep for UT on SWN-66-4 (required response to CR-IP2-2010-5414, a second pinhole was discovered. The pinhole was agitated by the prep work and a spray of water developed.	09/01/2010
CR-IP2-2010-5414	Sys Engineering walkdown identified three pinhole leaks: SWN-66-1-22, SWN-66-2-23, and SWN-66-4-22. Pinholes at these couplings have been identified and evaluated in the past (see CR-IP2-202-7051, and CR-IP2-2009-5169).	08/31/2010
CR-IP3-2015-5195	Extent of Condition inspections for service water leak documented in CR-IP3-2015-5136.	10/14/2015
CR-IP3-2015-3789	Small leak on 3-inch service water line #1224 (SW supply from 4-5-6 to CCR A/C units). Leak is at or near weld for flanged transition between carbon and stainless steel piping on this line.	07/08/2015
CR-IP3-2014-3328	Extent of Condition inspections for service water leak documented in CR-IP3-2014-3217	12/22/2014

Document	Title/Description	Revision/Date
CR-IP3-2014-2611	Small thru-wall service water leak from 90-degree elbow downstream of SWT-19 (31 THCC Hx SW Outlet Isolation).	10/24/2014
CR-IP3-2014-2610	Small service water leak (<1 drop per minute) through side wall of SWT-20-1 (TCV-1109 inlet isolation).	10/24/2014
CR-IP3-2014-2609	Slight leak (<1 drop per minute) from an unused pipe tap (welded) off of the 8-inch service water supply line for the SG blowdown recovery and turbine hall closed cooling.	10/24/2014
CR-IP3-2014-2062	Pinhole leak on service water connection to SG blowdown recovery heat exchanger.	08/30/2014
CR-IP3-2014-0070	Service water leak through body of valve SWT-31-1 MBFP lube oil cooler inlet relief valve. Leak rate is approximately 1 drop per 5 minutes.	01/07/2014
CR-IP3-2013-4344	Leak on elbow associated with vacuum breaker on 34 SWP.	10/23/2013
CR-IP3-2013-4174	Included with “corrective action listing”: Action 5 of CR-IP3-2013-4174 requires five additional inspections per ASME Code Case N-513-3.	Not available
CR-IP3-2013-1877	Internal inspection of pipe with SWN-41-4 removed under WO-270327-01, found 2-inch wide band of severe corrosion around entire circumference of the weld due to missing cement lining in this area.	03/21/2013
CR-IP3-2013-1671	Two leaks in ¾-inch service water vent pipe on the 24-inch SWN #408 header, just upstream of SWN-106-2. The horizontal line just downstream of the leaks had been replaced during 3R17.	03/17/2013
CR-IP3-2013-0668	While prepping pipe weld 02-010 for UT exam, noticed it had a thru-wall leak.	02/19/2013
CR-IP3-2013-0507	Small steady-stream leak coming from top of service water downstream of SWN-6 and SWN-7. This leak is in the west service water valve pit. [Possibly similar to leak in LER 286/2011-003]	02/06/2013
CR-IP3-2013-0504	Volumetric exam (UT) of weld ID IS-46 in service water system on 14-inch line #1085 found locations below the required 2-year wall thickness as stated in Calc P-CALC-12-00104. Required extent of condition inspections per ASME Code Case N-513-3.	02/06/2013

Document	Title/Description	Revision/Date
CR-IP3-2012-2544	Through-wall leak on 3-inch service water line to #31 MBFPT lube oil cooler, downstream of SWT-16-1.	08/20/2012
CR-IP3-2012-2193	Service water leak from weld on elbow upstream of 31CCW SW sample valve SWN-49-1.	07/16/2012
CR-IP3-2012-2150	Pinhole leak on 6-inch service water pipe just above the MBFP oil reservoir. Pipe taps off the main SW line upstream of PCV-1179/A. Line reduces to 4-inch pipe and supplies essential service water to MBFP lube oil coolers, and hydrogen side and air side seal oil coolers.	07/11/2012
CR-IP3-2012-0089	Through-wall leak on weld at inlet of TCV-1109 between SWT-20-1 and TI-1315.	01/05/2012
CR-IP3-2011-1056	Adverse trend. 3R16P NRC GL 89-13 inspections of SW welds PAB-7, -8, -9, -26, and EOC-26 found pipe wall degradation and metal wall thickness losses in varying degrees. All welds have had previous weld repairs in 1999 or 2001. It appears that the station methodology for repairing SW weld leaks and corrosion wall losses are inadequate to allow the expected long life. There are numerous other examples of previously repaired SW pipe welds leaking again or having unacceptable wall thinning when examined during subsequent GL 89-13 exams.	3/10/2011
CR-IP3-2011-0680	Leak in west service water pit. Service water leak of approximately 150 gpm is on the piping downstream of SWN-6 and SWN-7 which supplies conventional essential service water. [Associated with LER 286/2011-003]	02/22/2011
CR-IP3-2008-2514	Inspection during PM [preventive maintenance] of U3 31A & 31B CCRAC Hx revealed evidence of thru-wall leak in copper/brass SW supply manifold piping to Hxs. Equipment listed as “Inoperable.”	10/09/2008
CR-IP3-2008-1318	Service water leak from #32 FCU. Based on correlation between weir level and leak rate, flow rate was approximately 7 gpm. Equipment listed as “Inoperable.”	06/06/2008

Based on its review of the documentation identified above and discussions with Entergy’s onsite and contractor staff, the NRC staff identified three separate categories of recurring internal corrosion (bolded headings below). In addition, the NRC staff noted one commitment change made to Entergy’s Generic Letter (GL) 89-13 program with potential impacts on the aging

management of the service water system. The NRC staff plans to issue an RAI regarding the issues discussed below to ensure that they have been properly resolved.

1) **Internal coating/lining issues**. As described in Licensee Event Report (LER) 286/2002-001, the design of the cement-lined service water system piping includes a small gap between the ends of the cement liner on each side of the weld joints to prevent damage to internal cement liner caused by the heat of welding during construction. The weld joints may have isolated areas containing a slight crevice at the root of the weld and the slight gap in the cement liner permits brackish service water to contact the bare metal of the weld. This gap results in corrosion of the weld metal over time and also permits water to seep under the cement liner causing the corrosion of the base metal.

    a) As noted in LER 286/2002-001, a leak in service water pipe resulted in the identification of insufficient structural integrity due to corrosion at a weld for an 18-inch pipe. Reviews of prior inspections did not reveal precursors to the corrosion of the pipe such as missing concrete lining or biological growth. The initial license renewal application did not discuss this previous operating experience that resulted in a loss of intended function and it was unclear that effective changes have been made to ensure future, similar loss of structural integrity will not occur in other cement-lined piping.

    b) LER 286/2011-003, (reference CR-IP3-2011-0680) describes a safety system functional failure of the service water system caused by flooding of an associated valve pit. Based on the LER, two aspects warrant consideration:

        i. Previously repaired leaks. The cement lining inside the pipe was not appropriately repaired/replaced in 1992, and the size of the subsequent leak was much greater (150 gallons per minute) than the nominal leak rates (drops per minute) that are typical for most service water system leaks. Although program changes addressed future lining repairs, it was not clear whether reviews of all previous leak repairs had been conducted in order to provide reasonable assurance that similar defective lining repairs with the potential for comparable leak rates do not exist.

        ii. Flooding locations. The substantial leak in a service water valve pit caused flooding that resulted in a safety system functional failure. During its review of condition reports (CR) for other service water leaks, the NRC staff noted that CR-IP3-2008-1318 identified that the leak rate was approximately 7 gpm. When considering probable leak rates, it was not clear whether reviews of other potential flooding locations had been conducted in order to provide reasonable assurance that similar safety system functional failures will not occur.

2) **Pitting and crevice corrosion in stainless steel piping**. As discussed in LER 247/2013-004, some cement-lined service water piping was replaced with stainless steel in the late 1980's. Pin holes were subsequently identified in the replacement piping in 2008, and corrective actions included the scheduled replacement of the 300 series stainless steel with highly corrosion resistant material (AL6XN) in 2010. However, pipe replacement was deferred to 2012 and again to 2014 due to higher risk work. During its review of operating experience associated with service water leaks, the NRC staff

identified CR-IP2-2013-5053, CR-IP2-2014-1179, CR-IP2-2014-6504, and CR-IP2-2015-3500 that resulted in the associated radiation monitors R-49, R-46, and R-53 being nonfunctional or inoperable. Entergy's discussions about recurring internal corrosion in its letter dated December 16, 2014, did not appear to address the loss of intended function due to these service water leaks. In addition, the associated LER states "pitting corrosion in stainless steel piping is expected to be fully mitigated by the outage in 2014 when the piping for the radiation monitor system is replaced." However, because CR-IP2-2014-6504 and CR-IP2-2015-3500 occurred after the 2014 outage, it is unclear why the stainless steel pitting corrosion continues.

3) **Corrosion in low flow or stagnant vent or drain lines**. As discussed in LER 286/2014-002:

> An extent of condition review identified system operating history with recurring problems with leaks developing in stagnant vent and drain connection piping and valves. Procedure 3-PT-R185B, (Primary Auxiliary Building SW Piping and Valve Flush) was developed specifically to address this issue. […] Procedure 3-PT-R185B is performed on a two year frequency and is the main line of defense for preventing future leaks in small bore carbon steel piping socket welds.

Based on discussions with onsite personnel, the flushing procedure had been performed in the portion of the piping that developed the leak identified in LER 286/2014-002. Given that the flushing procedure is intended to prevent future leaks, the effectiveness of this procedure is unclear. In addition, Entergy's letter dated August 18, 2015, states that a section was added to the Service Water Integrity Program governing procedure "when it was noted that Unit 2 did not have a procedure equivalent to the Unit 3 flushing procedure, 3PT-R185B." It was unclear whether reviews had been conducted to provide reasonable assurance that corresponding procedures for each unit were in place for all activities being credited by the aging management program.

4) The site's implementing procedure for the Service Water Integrity Program is "Indian Point Energy Center, NRC Generic Letter 89-13 Service Water Program." The NRC staff notes that the GL 89-13 program was not developed as an aging management program and consequently, some ongoing portions of the program may not be associated with aging management activities. As an example, Entergy's letter dated August 18, 2015, states that the program change in February 2012, (which increased the service water pump bay sonar inspections from a 2-year to a 3-month frequency as discussed in LER 247/2011-003), "was not made to manage the effects of aging, but to better manage the effects of weather-related events." GL 89-13 does not differentiate between event-driven (i.e., weather related) and normal aging effects such as silting due to river flow. It is not clear which aspects of GL 89-13 are being credited for aging management activities. In addition, Entergy changed its GL 89-13 commitment in December 2010 for inspecting the service water intake bays. The revised commitment deleted the refueling outage frequency and now only specifies tasks "on set frequencies." Although the Service Water Integrity Updated Final Safety Analysis Report Supplement states that the program relies on implementation of the recommendations of GL 89-13, the recent commitment change is no longer consistent with the recommendations of GL 89-13 for the maximum span of time between intake structure inspections. As a result, it is not clear that silting of the service water intake bays will be appropriately managed during the period of extended operation.

4. Exit Meeting

A final briefing was held with Entergy on February 25, 2016, to discuss the results of the supplemental audit. On March 3, 2016, the NRC staff and Entergy participated in a telephone conference call to clarify the discussion from the February 25, 2016, exit meeting. Specifically, Entergy explained that the apparent discrepancy between operating experience identified by the NRC staff and Entergy's responses to RAIs, as noted in RAI 3.0.3–3 and discussion topic 2.f from the NRC staff's December 2015 audit plan, resulted from the fact that Entergy had determined that the issues identified in the LERs were not applicable for consideration within the scope of the review of the LRA based on the specific circumstances of the leaks. As such, Entergy did not identify those LERs in their RAI responses. The NRC staff stated that it intends to address any potential discrepancies in a future RAI.

5. Audit Participants

The following staff from the NRC and Entergy participated in this supplemental audit:

PARTICIPANTS:	**AFFILIATION:**
Brian Allik	U.S. Nuclear Regulatory Commission (NRC)
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Clay Wilson	Entergy
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