General Electric Advanced Technology Manual

Chapter 4.1

Buried Piping

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4.1 BURIED PIPING

Learning Objectives:

1. Recognize the nuclear safety, radiological and environmental consequences of leakage from buried piping and tritium leakage into the environment.

2. Identify the major causes for degradation in buried piping integrity.

3. Recognize the regulations that apply to buried piping integrity, including Part 20, Part 50 and state and local environmental regulations.

4. Identify the major components in the industry's Buried Piping Integrity Initiative.

5. Identify the major components in the industry's Groundwater Protection Initiative for coping with the issue.

4.1.1 Operating Experience

Operating experience at multiple nuclear sites has led to NRC, congress and public interest in buried piping leaks. Key to this, for inspection, is the inability to actually see the "faulted" component. A second problem with underground piping leaks is that contamination in groundwater onsite may migrate offsite without detection. The licensee is required by NRC regulations to perform offsite environmental monitoring, depending on the leak location, the leak may not be detected. Furthermore, even if groundwater contamination is detected, it is difficult to predict the movement of the contamination in the groundwater. Some examples of these leaks are listed in the following paragraphs.

In August 2004, Dresden detected contaminated ground water in onsite monitoring wells that had been installed due to historical leaks related to the condensate storage tank. The contaminated water was due to a leaking underground pipe connected to the condensate storage tank. Onsite sampling identified tritium levels consistent with those present in the condensate storage tank of about 8,000,000 pCi/L.

In March of 2005, at Braidwood, the Illinois Environmental Protection Agency notified the licensee of tritium in wells in a nearby community. The licensee began monitoring ground-water between the community of Godley, Illinois, and the Braidwood Nuclear Power Plant (Braidwood). The licensee had measured levels as high as 58,000 picocuries per liter (pCi/L). The licensee attributed the contamination to historical leakage of vacuum breaker valves along the circulating water blowdown line. Between March 2005 and March 2006, the licensee identified tritium levels between 1,400 and 1,600 pCi/L in one residential drinking water well. In addition to the nearby homeowner's wells, the licensee sampled the ground water onsite and offsite, and found tritium levels as high as 250,000 pCi/L.

In March, of 2006, at Palo Verde, a water sample collected from a test well identified tritium levels of 71,400 pCi/L. Tritium was found in Units 2 and 3 subsurface soils, but only Unit 3 indicated tritium levels above the EPA drinking water standard. Plant staff concluded that the elevated onsite tritium contamination was due to past operational practices during boric acid concentrator system (evaporator system) releases. It was determined that the tritium contaminated water at elevated levels was confined onsite.

In May, of 2006, at Three Mile Island, the licensee identified an access manway for underground telephone cables to be a source of leakage. The licensee identified that the water had come from the condensate system and had reached the manway via an underground telephone cable conduit run. The contaminated water had entered a telephone cable raceway inside of the building and from their flowed into the telephone cable conduit run.

In January, 2010, the Vermont Yankee (VY) nuclear plant provided a report to NRC that a routine sample from a groundwater monitoring well indicated tritium levels of 17,000 pCi/L. The monitoring well was located outside the protected area but within the owner controlled area, about 30 feet from the Connecticut River. Entergy established an evaluation team to determine the source of the tritium, developed sampling plans and added additional groundwater monitoring wells. Entergy also conducted further hydro-geological surveys and data collection to better characterize groundwater behavior on the site. Entergy's bounding analysis confirmed that the consequence of this leakage would not affect public health and safety or exceed any NRC regulatory requirements. Entergy determined that the groundwater contamination resulted from an underground concrete pipe vault associated with the Off-Gas system. Although tritium was identified in on-site groundwater monitoring wells, and the NRC staff did not identify a hazard to public health and safety, however, an extraordinary level of interest by congressional, state, and local officials, the NRC increased it's oversight of the characterization, mitigation, and remediation of the tritium contamination. The NRC determined that Entergy appropriately evaluated the contaminated groundwater with respect to effluent release limits and the resulting radiological impact to public health and safety. It was also verified that Entergy complied with all applicable regulatory requirements.

In December 16, 2011, Sequoyah detected elevated levels of tritium in water samples taken from a new onsite monitoring well. The tritium levels were confirmed to be greater than 20,000 pCi/L threshold for drinking water. Samples taken in the discharge channel located 30 yards from this groundwater monitoring well confirmed no detectable tritium. Refueling Water Storage Tank levels are being monitored and no active leak is in progress. Samples of adjacent wells were taken and confirmed no unexpected changes in tritium levels of these wells.

4.1.2 Overview

The potential nuclear safety aspect of buried piping is the inability to detect a problem until it has actually failed. As an example, if an underground service water pipe that supplies the emergency diesel generators fails, the diesel will fail. The same would be true for any buried piping that supplies a safety system such as ECCS room coolers, or component cooling of ECCS or support systems. The actual safety significance of the majority of underground piping leaks has been “low” based upon the Reactor Oversight Process (ROP). All underground piping leaks to date have been at most “Green”, if they even reached the threshold for a finding.

Buried piping leaks have been responsible for releases of low-level radioactive material and diesel fuel oil. The types and amounts of radioactive material or chemicals that have been released are at levels that are often a small fraction of the regulatory limits.

There are two primary components to radioactive water leaks, tritium and Strontium 90.

Tritium, a hydrogen isotope is a low energy beta emitter, it is not dangerous externally, but it is a radiation hazard when inhaled, ingested via food or water, or absorbed through the skin. Tritium has leaked from 48 of 65 nuclear sites in the United States. Due to the low energy of the emitted beta, Tritium is not a severe health hazard. The EPA limit for drinking water is 20,000 pCi/L. Nuclear power plants release varying amounts of tritium, depending on the amount of liquid waste discharged via normal and abnormal release discharge paths and the type of reactor. PWRs typically have higher tritium releases than BWRs. In 2003, the average PWR released about 700 curies of tritium in liquid effluents and the average BWR released about 30 curies of tritium in liquid effluents.

Strontium-90 (Sr-90) is a radioactive isotope produced in nuclear fission, with a half-life of about 29 years that emits a beta particle as it decays. Sr-90 may also be found still in the environment from weapons testing or the Chernobyl accident. Strontium-90 is referred to as a "bone seeker." Internal exposure to Sr-90 is linked to bone cancer, cancer of the soft tissue near the bone, and leukemia. The risk of cancer increases with increased exposure to Sr-90. The total annual release of strontium-90 into the atmosphere from all 103 commercial nuclear power plants operating in the United States is typically 1/1000th of a curie. (NUREG/CR-2907, Vol. 12) Radiation doses from Sr-90 to individuals living within 30 miles of a nuclear power plant would be a tiny fraction of one millirem.

The environmental risks include the radioactive isotopes and environmental damage from leaks such as fuel oil from underground tanks and piping for emergency diesel generators.

4.1.3 Buried Piping and Underground Tank Failure Mechanisms

Buried piping is susceptible to corrosion from the surrounding soil or from the material inside of the pipe or tank. These failure mechanisms include;

- Moisture in the soil causing rust through of a carbon steal pipe
- Inadequate piping coatings or poor application of coatings allowing moisture and chemicals in the soil to damage piping
- Internal corrosion of the piping (raw water systems) where the pipe rusts from the inside out.
- Acids or caustic materials corroding the piping or tank internally
- Flow accelerated corrosion cause by the flow of the fluid through piping
- Galvanic corrosion
- Microbiologicals
- Manufacturing defects in piping or tanks that provide a weak spot for corrosion or erosion to cause a failure.
- Worker installation practices that damage the pipe or tank during installation, leading to the eventual failure of the component.
- Heavy equipment that passes over buried piping, causing it to flex and fail.

Any of these individually or in combination can cause piping or underground tanks to start leaking. Once a leak has begun it can be enlarged based upon erosion due to the passage of the fluid out of the system. In addition to piping failures, tanks located below grade in a building can leak, putting water onto the floor of a concrete structure. If the concrete is not sealed or has cracked, the radioactive fluids can leak into the groundwater.

4.1.4 Buried Piping Regulations

For the release of radioactive liquid effluents, the NRC imposes specific requirements contained in 10 CFR 50.36a and detailed in Appendix I of 10 CFR 50. These requirements are structured to maintain the dose to members of the public from radioactive effluent releases to levels that are ALARA. The NRC regulates radioactive effluents from nuclear power plants based on the calculated doses to members of the public from the effluents, not specifically on the total volume or type of radioactive material discharged. The NRC requires licensees to have radiological effluent release technical specifications (RETS) that contain ALARA dose criteria from Appendix I. The <u>liquid</u> radioactive effluent annual and quarterly dose controls are as follows:

1. Liquid effluents shall not produce doses to any member of the public of more than 3 mrem to the total body or 10 mrems to any organ in a year.
2. Liquid effluents; during any calendar quarter, the dose shall be limited to less than or equal to 1.5 mrems to the total body and to less than or equal to 5 mrems to any organ.

10 CFR Part 20 also establishes standards for protection against ionizing radiation resulting from all activities conducted by NRC licensees. These regulations control the

receipt, possession, use, transfer, and disposal of licensed material. 10 CFR 20.1301 requires licensees to operate their facility so that the total effective dose equivalent (TEDE) to a member of the public does not exceed 0.1 rem (100 mrem) in a year. This limit is based on the impact from all radioactive gaseous and liquid effluents and any direct radiation from the plant, on-site storage facilities, and tanks containing radioactive fluids.

10 CFR 20.1301(e) requires nuclear power reactors to comply with the EPA's radiation protection standards in 40 CFR Part 190. This standard places limits on annual dose to a member of the public to less than or equal to 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

10 CFR 20.1501 requires that "each licensee shall make or cause to be made, surveys that may be necessary for the licensee to comply with the regulations.

The principal radiological effluent and environmental monitoring regulatory basis is contained in General Design Criteria 60, 61, and 64 of Appendix A of 10 CFR Part 50, and in Section IV.B of Appendix I of 10 CFR Part 50. "The licensee shall establish an appropriate surveillance and monitoring program to:

1. Provide data on the quantities of radioactive material released in liquid and gaseous effluents.
2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure.
3. Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure."

Plants are required by 10 CFR 50.34a to submit a description of the equipment and procedures for the control of radioactive effluents and for the maintenance and use of equipment installed in radioactive waste systems. The objective of this requirement is for licensees' routine operations to include the use of radioactive waste systems to keep levels of radioactive material in effluents ALARA. 10 CFR 50.36a requires licensees to have technical specifications which both comply with the public dose limits in 10 CFR Part 20 and require the use of operating procedures and radioactive waste systems to maintain radioactive effluents ALARA.

Licensees accomplish this, primarily through their Radiological Environmental Monitoring Program (REMP). The REMP requires various off-site samples to be taken. The location and type of samples include airborne and waterborne mechanisms, as well as ingestion pathways, typically of milk and fish. Samples are taken at required intervals and analyzed for radiological activity. The NRC inspects each licensee's effluent and environmental monitoring programs once every two years. The results of each licensee's radiological environmental monitoring and effluent controls programs are required to be reported annually to the NRC. The results of the REMP are intended to supplement the results of the radiological effluent controls program by verifying that any measurable concentrations of licensed radioactive material and levels of radiation in the environment are not higher than expected on the basis of the effluent measurements and modeling of the exposure pathways.

4.1.5 NRC Actions

Staff Evaluation of the Issue for Resolution 2009-13, “Underground Piping Leakage Concerns” was performed by the NRC to evaluate the safety significance of underground piping leaks.

The staff reviewed operating experience related to buried piping degradation, current regulations, and ASME Code requirements. They determined that the requirements were effective in ensuring that the structural integrity and functionality of buried, safety-related piping are maintained. Current regulations have also been effective in ensuring unintended releases of hazardous material to the environment from leaks in buried piping remain below regulatory limits. The staff did not recommend regulatory changes to address degradation of buried piping. Based on the review, operating experience lessons learned, and system insights gained staff determined this issue warranted continued evaluation and trending.

In 2009 the chairman tasked the agency staff to review its approach for overseeing buried piping at commercial nuclear power plants. The tasking followed recent incidents of leaking buried pipes at several plants including Vermont Yankee, Oyster Creek and Oconee.

The staff was asked to provide the Commission with an information paper to explain both ongoing and planned activities that address leaks from buried piping. The Chairman also asked the staff to discuss actions or plans regarding;

- Evaluate the adequacy of NRC requirements for designing, inspecting, and maintaining safety-related buried piping, including rules governing operating reactors, reactor license renewal, and new reactor licensing
- Evaluate the adequacy of American Society of Mechanical Engineers Code for designing, inspecting, and maintaining safety-related buried piping
- Evaluate the effectiveness of current rules and voluntary initiatives for designing, inspecting, and maintaining all nuclear power plant buried piping in ensuring public health and protecting the environment
- Recommend any revisions to existing regulations, requirements, practices, or oversight regarding the integrity of buried piping

The outcome of this was in SECY-11-0019, the Senior Management Review of the Overall Regulatory Approach to Groundwater Protection. This determined that no new regulations were required at this point, but that the NRC should continue to work with the industry to improve their initiatives. The NRC should also use the annual ROP self assessment to determine if a more leading indicator should be developed for degraded performance. These items along with improved communication and a standard communications protocol will manage the current groundwater and underground piping issues.

In 2011 a temporary instruction 2515/182-01 was issued for inspecting buried piping in two phases.

Phase 1 concentrates on consistency between the initiative and the licensee program.
- Are attributes in sections 3.3A and 3.3B of NEI 09-14 being met in the
- Licensee program?
- Are completion dates in licensee program similar to those recommended in NEI
- 09-14?
- Has licensee completed appropriate items?

Phase 2 will verify the completion dates in Phase 1 and concentrates on implementation of the NEI requirements. The inspector may review any additional programmatic aspects that may reveal either good or poor practices.

4.1.6 Industry Buried Pipe Initiative (NEI 09-14)

The initiative was unanimously approved by the industry chief nuclear officers, and required that each nuclear power plant site have a site-specific plan in place by July 31, 2006 and was updated in December 2010. The intent of the plans was to improve management of radiological releases to the groundwater and prevent migration of licensed radioactive materials offsite. The initiative called for enhanced reporting of events, benchmarking of industry best practices, and potential standardization of some practices.

The scope of the Underground Piping and Tanks Integrity Initiative includes;
1. All piping that is below grade and contains any fluid and is in direct contact with the soil (those within the scope of the original Buried Piping Integrity Initiative) and
2. Underground piping and tanks that are outside of a building and below grade (whether or not they are in direct contact with the soil) if they are safety related or contain licensed material or are known to be contaminated with licensed material.

The Underground Piping and Tanks Integrity Initiative is intended to drive proactive assessments and management of the condition of piping and tanks falling within the initiative scope. It also ensures sharing of industry experience and driving technology development to improve available techniques for inspecting and analyzing underground piping and tanks.

The elements, attributes, and milestones were established by the original Buried Piping Integrity Initiative, approved in November 2009.

Based on this initiative a risk prioritization was to be performed by Dec 31, 2010 and incorporate the following attributes:
- Piping function
- Pipe locations and layout
- Pipe materials and design

- Health of cathodic protection systems, if applicable
- Based on the above, determine:
  - The likelihood of failure of each piping segment
  - The consequences of failure of each piping segment
- A means to update the risk ranking
- A database to track key program data, inspection results and trends.

Based on the above data and other information, the likelihood of failure for each component was determined, along with the consequences of failure for the component. Actions are then taken to both inspect the piping and to prevent piping failure. As a means of determining the initiatives effect, significant leaks from underground piping and tanks across the industry will be trended for these components.

Building upon the existing Groundwater Protection Initiative, the Proposed Buried Piping Integrity Initiative was approved by the NSIAC in November 2009. This initiative called for:

- Procedures and oversight by June 30, 2010
- Risk ranking of buried pipe by Dec. 31, 2010
- An inspection plan by June 30, 2011
- Plan implementation no later than June 30, 2012 with the assessment of buried piping containing radioactive material by June 30, 2013
- And an asset management plan in place by Dec 31, 2013.

4.1.7 NEI Groundwater Protection Initiative (NEI 07-07)

The NEI Groundwater Protection Initiative was unanimously approved by the Nuclear Strategic Issues Advisory Committee (NSIAC) and adopted by US commercial nuclear power plants in May 2006. This initiative required that each nuclear power plant site have a site-specific plan in place by July 31, 2006. The intent of this was to improve management of radiological releases to the groundwater and prevent migration of licensed radioactive materials offsite. The initiative called for enhanced reporting of events, benchmarking of industry best practices, and potential standardization of some practices. In parallel, the NRC formed the Liquid Radioactive Release Lessons Learned Taskforce to assess the inadvertent release of radioactive liquids at reactor sites.

NEI 07-07 was developed to describe the industry's actions to improve utilities' management and response to the inadvertent release of radioactive substances in subsurface soils and water. The inadvertent releases addressed by this are outside the requirements of the NRC and are below the NRC's limits that protect public health and safety. Planned liquid and airborne releases, in accordance with NRC's regulations are not included in this initiative.

There are 5 basic objectives to this initiative;

1. Ensure that the site characterization of geology and hydrology provides an understanding of predominant ground water gradients based upon current site conditions.
2. Identify site risks based on plant design and work practices:
   - Evaluate all systems, structures, or components (SSCs) that contain or could contain licensed material for which there is a credible mechanism for the licensed material to reach ground water.
   - Evaluate work practices that involve licensed material for which there is a credible mechanism for the licensed material to reach ground water.
3. Establish an on-site ground water monitoring program to ensure timely detection of inadvertent radiological releases to ground water.
4. Establish a remediation protocol to prevent migration of licensed material off-site and to minimize decommissioning impacts.
5. Ensure that records of leaks, spills, remediation efforts are retained and retrievable to meet the requirements of 10 CFR 50.75(g).

4.1.8 Summary

The final report of the NRC’s Liquid Radioactive Release Lessons Learned Taskforce was issued on September 1, 2006 and included twenty-six recommendations for additional consideration by the NRC. The report stated: “The most significant conclusion of the task force regarded public health impacts. Although there have been a number of industry events where radioactive liquid was released to the environment in an unplanned and unmonitored fashion, based on the data available, the task force did not identify any instances where the health of the public was impacted.”

Although buried piping and groundwater contaminations have not had a major impact on public health and safety, they do pose an issue for public confidence in the NRC’s and the industries ability to safely operate nuclear power plants. In addition, it cannot be ruled out that a tank or buried pipe failure could have an impact on a critical safety system during plant accident conditions. As the two industry initiatives are commitments by the utilities, they fall under our inspection regimes as much as the regulations in 10CFR 20 and 10CFR 50.