Inspection, repairing methods and consequences of buried piping failure in nuclear power plant

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1. Introduction

The common use of buried piping in nuclear power plant is the transfer of cooling water (circulating and feed water. Damage to buried piping can lead to limitations on the operation of nuclear power plants and risk of radiation leakage, so proper maintenance and prevention methods are applied and managed [1].

The degradation mechanisms of buried piping is due to corrosion, mechanical damage, and combined of both phenomena (Figure 1), which are caused by poor design, inappropriate construction, improper maintenance (water treatment), and the use of unsuitable materials.

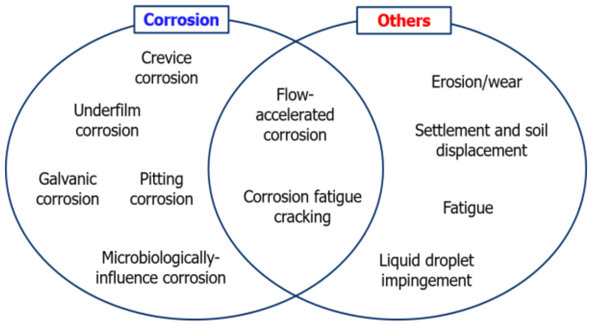

Fig. 1. Degradation mechanisms of buried piping in nuclear power plant.

The management and maintenance of buried piping in nuclear power plant is an internationally important concern. In the United State, NEI 09-14 (management program of buried pipeline) is applied to all nuclear power plant for the continuous monitoring of the degradation of buried piping. In addition, technical meeting among stakeholders (public, utility and government agencies) are continuously held to develop regulatory guidelines. In Korea, the licensee of nuclear power plant should plan and carry out the aging management program (AMP) by referring to NRC's NUREG-1801 XI.M41 "Buried and Underground Piping and Tanks", and are constantly sharing relevant operating experiences.

In this study, to understand the management status of the buried piping in nuclear power plant, the followings are investigated: ①how buried piping are inspected, ② how to repair it, ③the effects of failure of buried piping on the operation of nuclear power plants.

2. Inspection methods

Inspection procedures and techniques for buried piping commonly used are specified in NUREG-1801 and NEI 09-14. Inspection techniques are divided into direct inspection and indirect inspection. The direct inspection method is mainly composed of non-destructive examination, which evaluates the thickness and flaws, and it enables to distinguish the acceptable and unacceptable damages for continued operation of nuclear power plant. The indirect inspection methods is evaluating the change of the potential or the electromagnetic field through the current flow which is generated in the degradation part (the coating damage or corroded parts) of buried piping. Indirect inspection methods are not appropriate to determine the continuous operation of nuclear power plant, but they increase the economic and temporal efficacy in reducing inspection area and the number of inspection object. Typical direct and indirect inspection methods are listed in Table 1.

In the United State, direct and indirect inspection methods used in oil and gas pipelines are also applied in inspection of buried piping in nuclear power plant. Especially, the in-line inspection (ILI) uses non-destructive testing equipment in the form of a robot to perform real-time inspection of buried piping without restriction in operating nuclear power plant. In the direct inspection method using the robot, it is possible to perform a quick and economical direct inspection in situation where human accessibility is difficult. However, there is a lack of the research and development on the ILI technology in Korea. At present, nuclear power plant will require the application and development of efficient advanced inspection methods as they have been in operation for lone-time (several decades).

Table I: Type of direct and indirect inspections.

Type	Method
Direct	Magnetic flux leakage (MFL)
	Ultrasonic testing (UT)
	Hydrostatic testing
	Internal inspection
Indirect	Closed-interval potential survey
	Current voltage gradient
	Alternating current coating
	Area potential earth current survey

3. Repair methods for buried pipe failure

Replacing a damaged buried piping with a new pipe of the same or better quality is the most costly method of repair. The process is generally done by excavating the soil in the buried piping, cutting out a portion of the damaged part, and welding the new pipe. In this case, the important part is to block the flow of the internal fluid, or to control the flow of the fluid through the by-pass when the shutdown cannot be performed.

The repair method of the partial buried piping is divided into the welding and non-welding methods as listed in Table 2. The applicable standards for the repair are the ASME Section III for the piping of safety grade, and ASME B31.1, AWWA C604-06 for that of non-safety grade. The contents of repair method of partially buried piping mainly consist of filling defects in the leakage area through welding, suppressing leakage through mechanical fastening, and applying the lining.

Table Ⅱ: Repair methods for buried pipe failure [1]

Welded repair	Non-welded Repair
-Pipe replacement -Fillet welded patch -External weld overlay -Structural inlay -Cladding -Welded inset plate -Leak box -Peending and welding -Pipe cap	-Inverted liner -Slip lining -Mechanical clamp -Threaded repair -Leak strap -Wrap repair -Linings

4. Consequences of buried pipe failure in nuclear power plant

Damage to buried piping can have direct and indirect effects on the operation of nuclear power plants. The impacts of damage caused by the failure of buried piping are classified into the following 8 categories in OECD/NEA:

a. Fire protection (FP) pipe break with coincident fire suppression demand
b. Dual unit shutdown
c. Flooding of equipment area/utility tunnel
d. Unplanned outage work
e. Manual shutdown
f. Expanded outage work
g. No operational impact
h. LCO(limiting condition operating) entry

Although the degree of impact on the nuclear power plant differs depending on the category and extent of damage to buried piping, the management of buried piping is important due to the limitation of operating nuclear power plant and initiation of accident condition. In addition, the tendency of buried piping damage to increase with the operating time of nuclear power plant as shown in Figure 3, indicating that the management of buried piping failure with the operating time of nuclear power plant is important.

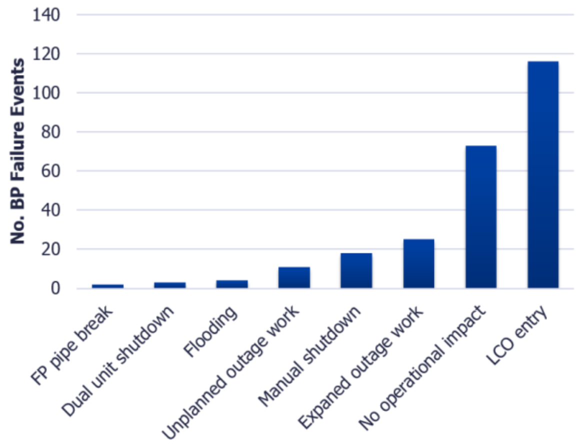

Fig. 2. Impact of buried pipe failure on plant operation [1].

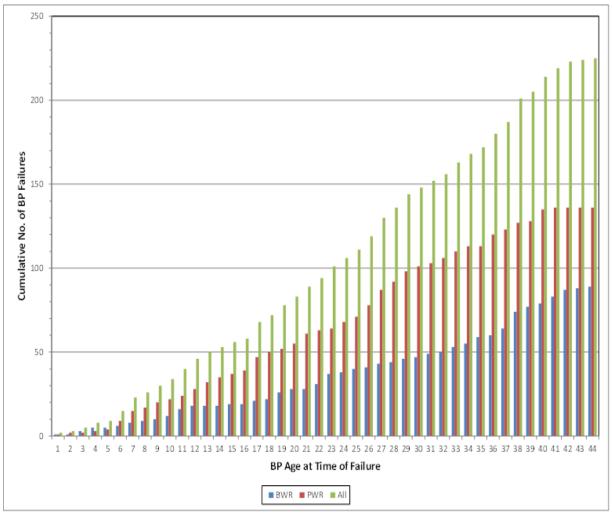

Fig. 3. The number of failure with the aging time of buried piping in nuclear power plant [1].

5. Conclusion

The damage of buried piping is increasing with the increase in operating time of nuclear power plant. Several direct and indirect inspection techniques have been applied in the filed for effective management. In Korea, however, equipment application and research for the ILI are insufficient. The repair method of the broken buried piping is divided into partial repairs (welding and non-welding) and whole replacement, and the applied technical standard are different depending on the safety grade. Damage to buried piping may lead to economics losses due to operational limitation of nuclear power plant and initiation of accident, so continued interests of licensee and regulatory body about the application of advanced inspection technology and development of effective regulatory guideline are needed.

REFERENCES

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