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Considerations in Repairing the Thinned Piping in Nuclear Power Plants

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1. Introduction

Thinning due to flow assisted corrosion has been occurred in the carbon steel piping in the nuclear plants. The thinning should be systematically managed against the failure of the piping. The management includes the inspection, analysis and repair/replacement. Each of the activities has its own criteria for the safety class piping. But as for the non-safety class piping, there is no clear code requirement for the management for the thinning. The thinning management for the non-safety class piping depends on the plant owner's policy. This paper has investigated the current procedures, requirements and repair methods related with the thinned piping. Based on the investigation, the optimized repair methodology and its basis which can be applied to the non-class piping is proposed.

2. Requirements for repairs of thinned piping

In the nuclear power plants, thinning has been usually occurred in the secondary piping which is non-safety class and made of carbon steel. The thinning mechanism is known as flow assisted (or accelerated) corrosion. For the non-safety secondary piping, ASME code XI has no inspection or maintenance requirement for the thinning. Different from the PWR (pressurized water reactor) type nuclear power plants, the CANDU type plant has the carbon steel piping in the safety class system and has the specific inspection and replacement requirement against the thinning of feeder pipes. According to the CAN/CSA-N285.4, the thickness of feeder pipes should be inspected periodically. If the thickness decreases 40% or more than initial thickness, the remedial action should be reported to the regulatory body. Conceptually, the ASME code does not require the inspection of the thinning of the base material but the flaw at the weld region of the piping or vessels. After many piping failures occurred because of the thinning, the ASME issued the Code Case N597-2 as an thickness acceptance criteria for the analysis and replacement. CCN597-2 can be applied to the internal or external thinning of the safety class 1, 2, 3 piping. According to the CCN597-2, the piping should be repaired or replaced in case the predicted thickness in the next outage reaches less than 30% of the nominal thickness for the class 1 piping, 20% for the class 2 or 3 piping. The piping can be used until next outage if its predicted thickness is 87.5% or more than the nominal thickness. If the thickness decreases less than 87.5% of the nominal thickness, the owner should demonstrate the fitness for service by analytic evaluation. Nonetheless, there is still no code requirement for the inspection or the maintenance of thinning of the non-safety class piping. The owner can decide its policy for the management of the non-safety class piping.

3. Repair Methodology

There are many repair methods which can be applied to the thinned piping when the thickness is predicted to be under the acceptance criteria. Some of them are included in the ASME code and others are not. All of the ASME class piping should follow the rule of ASME Sec. XI IWA-4000 for the repair/replacement of them. The philosophy of the ASME is to secure the integrity of the piping and minimize the possibility of leak. The ASME takes welding as a principle repair method. The basic repair method of the ASME is to remove the flaw and restore the removed part to original state by welding or to cut the defected piping and install with new one. According to the IWA-4320, it does not allow the expanded joints or threaded joints or clamping to the class 1 piping. Although the welding is a good repair method, it is sometimes difficult to perform because of the working condition. The ASME published the alternative repair method as CCN 561-1, 562-1, and mandatory appendix IX of Sec. XI. The CCN 561-1 and CCN 562-1 are the rules of exterior overlay welding for the thinned carbon steel piping of class 2 and class 3, respectively. The figure 1 is the conceptual drawing of exterior overlay welding depicted in CCN 561-1.

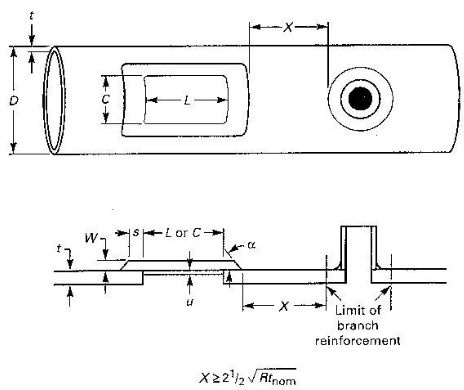

Fig. 1. Design concept of exterior overlay welding

The mandatory appendix IX allows the clamping method to the class 3 piping in the condition of using it only until the next outage. All of the repair/replacement methodology described in ASME can also be applied to the non-class piping, though it requires stringent rules to follow.

The document survey shows there are various repair methods which are widely used in the industry. Although those methods are not included in the ASME code, they can be applied to the non-class piping in the nuclear power plants with the decision by the utility. Here are some of them ; welded patch, full-encirclement welded split sleeve, welded leak box, mechanical clamp, mechanical clamp with seal injection, composite wrap sleeve, insertion liner, etc. The figure 2 shows the welded split sleeve.

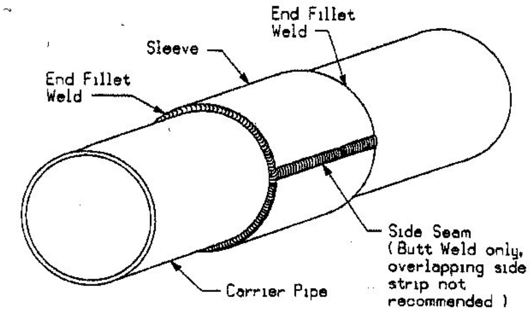

Fig. 2. Weled split sleeve

The applicability of them would be dependent on the working condition that is related with pressure, temperature, accessibility, fluid, etc. Some of them can be used temporarily to earn the time until the regular outage. An engineer should consider the fitness for service and durability before applying them to the plant.

4. Current Repair Practices

Three guidelines or procedures were reviewed; NSAC-202L of EPRI, NOECP-403 of Waterford 3 plant in U.S., standard maintenance procedure 10 of KHNP(Korea hydro and nuclear power corp.). The NSAL-202L is the most widely used guideline to manage the thinning of the carbon steel piping in the nuclear power plant. KHNP participated in the developing the NSAC-202L and uses it as a reference guideline of its procedure. NSAC-202L recommends weld buildup (or overlay) and clamping technique for repairing the non-safety class thinned piping. Although interior weld buildup is most favorable, it is often limited by accessibility. The design and methodology of exterior weld buildup were guided in the CCN 561-1 and 561-2. The clamping technique is recommended for only temporary repair. NOECP-403 uses only the weld buildup method as an option of the thinned pipe repair and ANSI B31.1 is used as an alternative reference. In the standard maintenance procedure 10 of KHNP, replacement is firstly recommended when the thickness is predicted to reach its criteria. The exterior weld buildup can be used only for one cycle and should be replaced with new piping in the following outage. It was found KHNP had the most conservative maintenance policy.

5. Conclusions and Suggestions

The current requirements, methodologies and practices for repairing the non-safety class carbon steel thinned piping were investigated. It was found that the nuclear industry had too conservative maintenance policy for the thinning of non-class piping. They are applying almost same requirements and repair methods of safety class piping to the non-class piping, although it is not required under the law. According to the review of the various technical codes, other repair methods such as welded split sleeve or welded patch are thought to be applicable to the repair of the non-class thinned piping in the nuclear power plant, if the rules described in the ANSI B31.4 or API 570 are observed.

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