Regulatory Status of Dissimilar Metal Weld (DMW)

K. C. KIM, J.K.Hong, H. S. SHIN, S. S. KANG, M. H. SONG, H. D.CHUNG
Korea Institute of Nuclear Safety,P.O. Box 114, Yuseong, Daejeon, Korea 305-, kck@kins.re.kr

1. Introduction

In this technical article, the regulatory status for Dissimilar Metal Water (DMW) was discussed. In order to decide the regulatory direction of DMW, the USA's accidents of PWSCC and their regulatory directions were reviewed. By reviewing their experiences, the Korean DMW regulation approach was decided.

2. Example of PWSCC

During the period of year 1999-2006, PWSCCs were found in alloy 82/132/182 butt welds of PWR plants around the world. On October 7, 2000, a large quantity of boron was identified on the floor and protruding from the air boot around the "A" loop RCS hot leg pipe in VC Summer Nuclear Power Plant in USA. UT, ET (eddy current testing) and VT (visual testing) were applied, and an axial crack-like indication was identified. The hot leg weld was cut out and destructively tested. The indication was determined to be an axial crack approximately 2.5 inches long and almost through wall which was caused by PWSCC[1].

During in-service inspections of Ringhals 3 in 1990 and Ranghals 4 in 2000, part-depth axial flaws were also found from Alloy 182 reactor vessel outlet nozzle to hot leg safe end butt welds.[2] In October 2002, an axial indication was discovered from a pressurizer surge line nozzle to safe-end butt weld at Tihange 2[3].

During an annual inspection in September of 2003, cracking and leakage were discovered on pressurizer safety and relief nozzles in Tsuruga Power Plant, Unit 2 in Japan. All of the flaws found were axially oriented and located in the welds. The flaws did not extend into the base metal. During refueling outage 15 in October 2003, an indication was detected in a surge line nozzle to-safe end dissimilar metal weld at TMI-1. Full structural weld overlay repair using machined TIG welding, temper bead process and alloy 52 filler material were performed to maintain weld integrity[4].

At Wolf Creek in October 2006, three indications were found in the pressurizer surge nozzle-to-safe end weld, and two separate indications were in the safety and relief nozzle-to-safe end welds. These findings paid significant attention to the current inspection schedules and plans. According to the USNRC requirement, the baseline inspection of pressurizer for the same type of nuclear power plant was to be finished by Spring 2008 [5].

3. Regulatory Approach in U. S. A.

Operating experience of U.S.A. has demonstrated that alloy 82/182 materials exposed to primary coolant water (or steam) under the normal operating conditions of PWR plants are susceptible to PWSCC. In May 2003, the industry adopted an initiative on materials management and issued Nuclear Energy Institute (NEI) 03-08, "Guideline for the Management of Materials Issues." In September 2005, MRP issued MRP-139, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline," which states that all PWR plants are to be implemented under the industry's proactive management of materials degradation initiative, NEI 03-08.

In 2006, the inspection identified five circumferential indications in the surge, relief, and safety nozzle-to safe end DM butt welds of wolf creek containing Alloy 82/182 that were significantly larger and more extensive than previously seen in the industry. NRC staff presented the results of a fracture mechanics for the UT indications found at Wolf Creek. There may be little or no time margin between the onset of leakage and rupture in pressurizer nozzle Alloy 82/182 DM butt welds containing flaws similar to those found at Wolf Creek. The staff assessed a number of options regarding what regulatory action to take to address this issue and concluded that the licensees needed to complete inspections or mitigations of the pressurizer nozzle Alloy 82/182 welds by the end of 2007, consistent with the baseline inspection schedule in the MRP-139 guidelines. The staff also concluded that licensees needed to implement interim enhanced leakage monitoring, and reinspect unmitigated pressurizer DM butt welds once every four years versus once every five years as permitted by MRP-139. In March 2007, the NRC staff issued Confirmatory Action Letters (CALs) to the licensees of 40 PWR power plants confirming commitments from those licensees to resolve concerns regarding potential flaws in specific RCS DM butt welds by the end of 2007. The remaining 29 PWR plants had either completed the requisite actions or do not have pressurizer welds susceptible to PWSCC. Nine of the plants receiving CALs did not have outages scheduled in 2007 and were planning to mitigate the DM butt welds during the spring 2008 refueling outages, based on a process allowed by NEI 03-08 to extend the schedule. These plants entrusted to the NRC staff to accelerate outages into 2007 if the industry was not able to demonstrate an adequate level of safety to the NRC.

Industry completed these analyses and documented the results in MRP-216, Revision 1. These results were provided to the NRC staff by letter dated August 13, 2007. The NRC staff completed the independent analyses to enable review and critique of the industry's analyses. From these analysis, the staff concluded that PWSCC, if present in pressurizer DM butt welds of the

nine plants analyzed, would progress through-wall and exhibit detectable leakage prior to causing a possible rupture event. Therefore, the conclusion of the NRC staff's safety assessment was that there was reasonable assurance that the nine plants addressed by the evaluation could operate safely until their next scheduled refueling outages in the spring of 2008 [6] .

4. Regulatory Status in Korea

In Korea, the starting day of PD (Performance demonstration) is scheduled by MEST(Ministry of Education and Science Technology) Notice 2008-23. PD of DMW was supposed to start June 2006. However, utility required the preparing time for DMW PD because U.S.A. also did not have enough persons to size PWSCC crack and suffers from similar problem in 2006. Therefore, DMW PD has been prepared by the utility step by step. In the first step (from June 2007 to Nov 2010), the utility has used EPRI PD certificate holder, equipment and procedure. During this step, Korean venders will prepare DMW mockups including site specific mockups and develop the inspection technique of DMW by individual research or international research, for example, PINC. Also, KINS required KEPRI to establish Korea DMW PD system until Nov. 2010. Currently, all nuclear power plants including PRZ DMW were inspected according to the utility alloy 600 management program and no crack was found. In the second step (since Nov 2010), utility will use Korea PD system.

For mitigation, pressurizer DMW of Kori 1 unit will peform full structural weld overlay (FSWO) during 2009-2010. All nuclear nuclear power plants having Pressurizer DMW will perform FSWO step by step until 2014. KINS will review the repair process connected to FSWO.

5. Conclusion

Based on operating experience, the NRC staff believes that MRP-139 and the MRP interim guidance letters, with the exception of the reinspection interval for unmitigated pressurizer DM butt welds as addressed by the CALs, will provide adequate protection of public health and safety for addressing PWSCC in butt welds for the near term pending incorporation by reference into 10 CFR 50.55a of ASME Code Case containing comprehensive inspection requirements

In conjunction with the activities discussed above, the NRC staff is monitoring the implementation of MRP-139 through its regional inspection program. The NRC issued Temporary Instruction 2515-172, "Reactor Coolant System Dissimilar Metal Butt Welds," in February 2008, to support staff oversight of DM butt weld mitigation and inspection activities that licensees are implementing in accordance with the industry MRP-139 guidelines. The NRC staff is monitoring the industry's MRP-139 inspections and operating experience and will use this information to determine if any additional regulatory actions are necessary [7] .

Based on USNRC experience, the KINS staff believes that KHNP alloy 600 program and FSWO of all NPP which follows the MRP-139 will provide adequate protection of safety for addressing PWSCC in butt welds. However, reinspection interval should be decided. After Code Case 770 is endorsed by NRC, the utility will revise their alloy 600 management program including the reinspection interval.

REFERENCES

[1] NRC Information Notice 2000-17 : Crack in Weld area of Reactor Coolant System Hot Leg Piping at V. C. SUMMER, United States Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, (2000)
[2] A. Jenssen, K. Norrgard, C. Jansson, J. Lagerstom, G. Embring and P. Efsing, "Structural Assessment of Defected Nozzle to Safe-End Welds in Ringhals 3 and 4, "Proceedings of Fontevraud V International Symposium on Contribution of Materials Investigation to the Resolution of Problems Encountered in Pressurized Water Reactors, SFEN, 2002, pp 43-54.
[3] L. E. Thomas, J. S. Vetrano, S. M. Bruemmer, P. Efsing, B. Forssgren, G. Embring and K. Gott, "High-Resolution Analytical Electron Microscopy Characterization of Environtally Assiasted Cracks in Alloy 182 Weldments, "Proceedings of 11th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Waster Reactros, ANS, 2003
[4] NRC Information Notice 2004-11 : Cracking in Pressurizer Safety and Relief Nozzles and in surge line nozzle, United States Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, (2006)
[5] USNRC Website http://www.nrc.gov/reactors/operating/ops-experience/pressure-boundary-integrity/weld-issues/index.html, "Reactor Coolant System Weld Issues"
[6] NRC Regulatory Issue Summary 2008-25, "Regulatory Approach for Primary Water Stress Corrosion Cracking of DMW in PWR system RCS piping.
[7] NRC Inspection Manual Temporary Instruction 2515/172