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Status of Performance Demonstration for Austenitic and Ferritic Piping Ultrasonic Examination in Korea

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1. Introduction

Korea Electric Power Research Institute (KEPRI) and Korea Hydro and Nuclear Power Company (KHNP) always understood that the safety of nuclear power plant is dependant upon the integrity of its materials, and developed the Korean Performance Demonstration (KPD) system in order to improve the in-service inspections.

In order to develop the KPD system, the following works were completed: 1) surveying the welds on the piping of all nuclear power plants in Korea, 2) surveying the bolt configuration of all nuclear power plants in Korea, 3) determining the number and type of test specimens, 4) designing the test and practice specimens, 5) developing quality assurance procedures for the fabrication of test specimens and system management, 6) developing standard manual ultrasonic test procedures, 7) fabrication and fingerprint of test specimens.

Before the implementation, round robin tests were conducted to evaluate the accuracy and reliability of examination result by comparing the results of DAC method and PD method in January 2004.

From April 2004, the KPD system for the piping was implemented. Until August 2005, 40 persons from 4 companies have been qualified for detection and length sizing in Piping, and 32 persons from 3 companies have been qualified for depth sizing in Piping.

2. Development of KPD system

2.1 Survey Results of Korean Nuclear Power Plant Configurations

A survey on the configurations of welds for piping was performed in order to design and fabricate the test specimens. These survey components were supplied by Westinghouse, Framatome, CE, and AECL. The survey results for the piping are shown in Table 1.

Table 1. The results of survey for piping in domestic PWR & PHWR plants

	Austenitic Piping	Ferritic Piping
Min. Diameter	2.0 in	4.0 in
Min. Thickness	0.22 in	0.337 in
Max. Diameter	24 in	42 in
Max. Thickness	1.6 in	4.4 in

Examples of abnormal conditions provided by the plant survey results are:

- Weld crowns wider than twice the pipe thickness
- Weld crowns which limit the coverage of the required inspection volume
- A number of ID counter bore transitions are within 4mm of the weld root
- Sharp counter bore conditions exist, which provide a signal response that requires evaluation.
- CANDU units contained the same types of geometric conditions as the PWR units.

2.2 Test Specimen Matrix, Number and Design

The specimen matrixes and numbers to be used in the KPD program were decided by plant survey results, as mentioned above, and satisfied ASME Code, 1995 edition and 1996 addenda. The bases of specimen sets and numbers are:

- Ferrite specimens include clad specimen
- Candidate number for each performance demonstration test is 15 (maximum)
- Detection specimen is 8 sets and sizing is 6 sets (If specimen mixed, the larger sets are used)
- 3 detection sets and 3 sizing sets for practice
- Practice specimen must satisfy the same manufacturing specification

The KPD has selected 0.237″ minimum thickness, 1.531″ maximum thickness, 2.0″ minimum diameter and 24″ maximum diameter for austenite specimens. The KPD also selects 0.337″ minimum thickness, 4.125″ maximum thickness, 4.0″ minimum diameter and 50” maximum diameter for ferrite specimens. The specimens have wide crown, counterbore, ground flush, diameter shrinkage, etc.

2.3 Fabrication and Fingerprint of Test Specimen

After designing the test specimens, KEPRI and KHNP started the fabrication of the test specimens at the beginning of December 2002 and obtained all the test specimens at the end of 2003. Before manufacturing the actual test specimens, the trial specimens, which are representative of the entire test specimens, were made to measure, evaluate, and analyze the flaws(location, length and depth, etc) by means of destructive method.

Figure 1 shows, the flaw depth measured by SEM. From this analysis of trial specimen, it was verified that the quality of fabrication by the appointed vendor could be met the requirements of the KPD manufacturing specification.

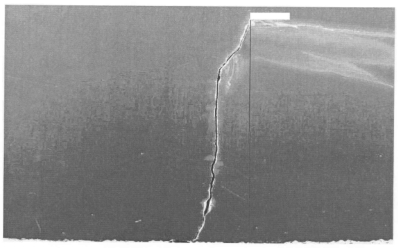

Figure 1. Sectional view of flaw depth

To verify that all the specimens have the intended flaws and no other extraneous signal exist, fingerprint for all the specimens was performed. Figure 2 shows the result of the UT for the specimens.

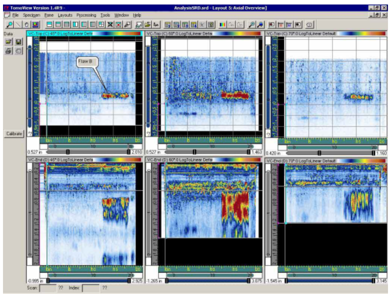

Figure 2. Result of the fingerprint

2.4 Round Robin Test

6 persons from 3 ISI vendors were participated in round robin test. The test specimens for detection and length sizing were composed of 7 austenitic piping and 4 ferritic piping. These 11 samples contained 7 thermal fatigue cracks and 5 mechanical fatigue cracks in view of flaw type and 11 circumferential cracks and 1 axial crack in view of flaw orientation. 6 wide weld crowns, 6 counterbores and 2 cladding conditions were included in these samples for geometry restriction. Round robin tests were performed by 2 different methods (DAC and PD methods). From the Figure 3, the results of the PD method are more precise than those of the DAC method and also fit better to the ideal line.

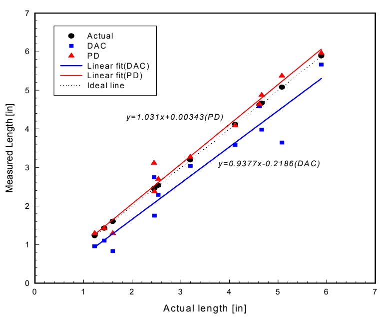

Figure 3. Estimated flaw length comparison

3. Implementation of Performance Demonstration

From April 2004, PD test for the piping was implemented. MOST announced Bulletin 2004-13 to implement performance demonstration of austenitic and ferritic piping in July 2004. Until August 2005, 40 persons from 4 companies have been qualified for detection and length sizing in Piping, 32 persons from 3 companies have been qualified for depth sizing in Piping.

Table 2. Performance Demonstration Results

Method	Test	1st (Pass/Trial)	2nd (Pass/Trial)	3rd (Pass/Trial)
Manual	Detection & Length Sizing	24/42 (57%)	39/42 (93%)	40/42 (95%)
	Depth Sizing	25/34 (74%)	32/34 (94%)	-
Auto	Detection & Length Sizing	1/3 (33%)	3/3 (100%)	-

4. Conclusion

KEPRI and KHNP had completed the KPD system to fulfill the performance demonstration requirements in ASME Sec. XI. Appendix VIII and MOST Bulletin 2004-13. From April 2004, PD test for the piping was implemented. Until August 2005, 40 persons from 4 companies have been qualified for detection and length sizing in Piping, 32 persons from 3 companies have been qualified for depth sizing in Piping.

By the enforcement of performance demonstration the following results are expected:

- Improvement of the reliability of in-service inspection results
- Standardization of inspection due to the usage of standard non-destructive testing procedures
- Providing qualified inspection personnel steadily
- Improvement of the level of non-destructive testing techniques

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