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# PARENT Program for DMW(Dissimilar Metal Weld) Reliability Assessment

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## 1. Introduction

Some cracks were found in dissimilar metal welds (DMW), which are connected with major components of nuclear power plants. Usually, the dissimilar metal welds are consisted of Alloy 600, carbon steel and stainless steel. Since 2000s, most of the cracks [1],[2] are found in welds, especially dissimilar metal welds such as pressurizer safety relief nozzle, reactor head penetration, reactor bottom mounted instrumentation (BMI), and reactor nozzles. Since the cracks are revealed as a primary water stress corrosion cracking (PWSCC), the reliability of non destructive evaluation (NDE) technique becomes more important.

To cope with the NDE reliability, PINC (program for inspection of nickel alloy components) international cooperation was organized. The aim of the project was 1) to fabricate representative NDE mock-ups with flaws to simulate PWSCCs, 2) to identify and quantitatively assess NDE methods for accurately detecting, sizing and characterizing PWSCCs, 3) to document the range of locations and morphologies of PWSCCs and 4) to incorporate results with other results of ongoing PWSCC research programs, as appropriate. Since the last KNS autumn meeting [3], the PINC program was finalized and the next program PARENT (Program to Assess Reliability for Emerging NDE Technique) is started on June this year.

In this study, as part of the PINC project, international RRT (round robin test) results for DMW will be introduced and the status of new PARENT program will be introduced.

## 2. Round Robin Test Results

### 2.1 Test Blocks

For the international NDE RRT(round robin test), 8 test blocks were used for DMW and 14 test blocks were used for BMI. There are 10 axial cracks and 15 circumferential cracks in DMW test blocks, and 17 axial cracks and 13 circumferential cracks in BMI test blocks. Fig. 1 shows one of the test block and its coordinate system.

### 2.2 Applied NDE techniques

The teams conducting the RRT used a wide mix of NDE techniques, ranging from standard methods such as conventional ultrasonic inspection to experimental techniques such as potential drop. Because there was a wide variety in techniques and the application of those techniques, comparing the effectiveness of the individual techniques would result in a very complex matrix. In this work, we will discuss their effectiveness and difficulties.

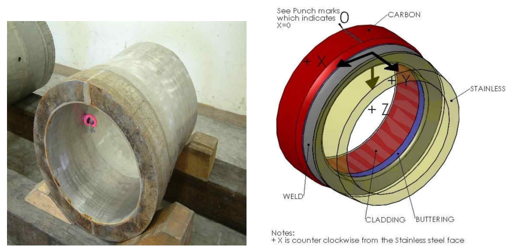


Fig. 1. One of the test blocks and coodinate system

### 2.3 Scoring example

Through a scoring procedure, detection and sizing results table and false call table was made and POD (probability of detection) also. Fig. 2 shows the indication associated with the detection as an example. The test block contains 12 flaws used for scoring (shown in red) and 2 poorly documented flaws that were not intentionally placed in the test block for the PINC studies but still are detectable (shown in blue). When the intersections between the called indications and the actual flaw locations are compared, one can determine how well the team performed.

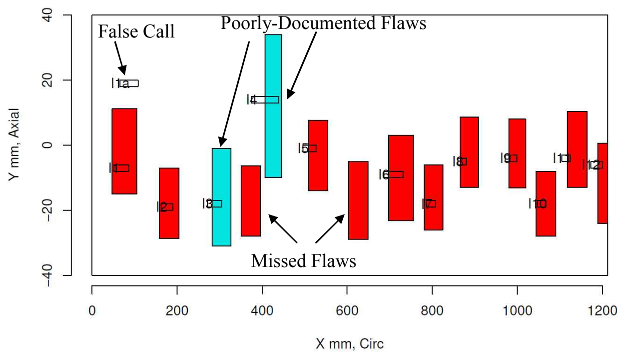


Fig. 2. Example of scoring inspection results

### 2.4 Results and Recommendation

In case of the DMW, eddy current inspection demonstrated the highest probability of detection(POD) for all flaws. The POD results show significant variability in POD performance based upon technique, procedure, and team. In case of the BMI, inspections using a single cross-coil eddy current probe achieved a high POD and a low false call rate. Inspections using adaptive phased array ultrasound were able to detect all baseline difficulty flaws. Fig. 3 shows POD curves for detection procedures in DMW test blocks

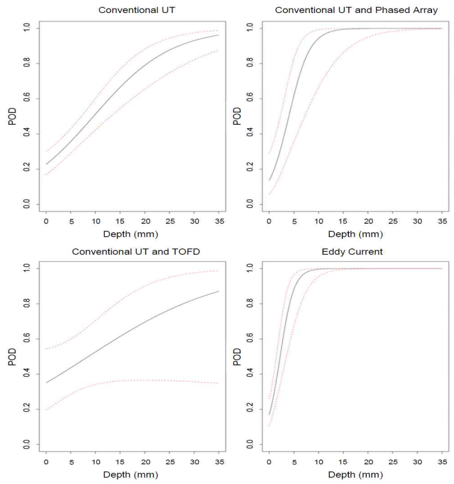

Fig. 3 POD Curves for Detection Procedures in DMW

For the flaw sizing performance, the depth sizing of flaws should be improved, because none of NDE techniques demonstrated the capability to accurately depth size flaws in DMW to ASME Section XI. The use of phased array UT and conventional ultrasound together showed the most promise.

In this study, we will discuss the results and recommendation more including the destructive material analysis.

## 3. PARENT for DMW

Since the last KNS meeting, the PINC program was terminated. In this previous international cooperation for NDE, we had several lessons learned such as qualification inspectors and procedures, sample design, etc. So to overcome these issues, the next phase program (PARENT) was launched on June this year.

### 3.1 Questionnaire for PARENT

Before the start of the PARENT RRT, the questionnaire was send round to all of the PINC member countries. The questionnaire results for the components of interest were scored to determine the priorities of the group. Table 1 shows the compiled scores for the each DMW component. BMIs were the highest priority items identified by the questionnaires by a wide margin. It shows that the interest was high for examinations of both the J-groove weld and penetration tube which are made from high susceptible PWSCC material. We will discuss more detail in KNS meeting.

Table 1 Compiled Scores for Each Component

| Component | Score |
|---|---|
| Bottom-Mounted Instrumentation Tube | 36 |
| Large-Diameter (≈30-inch-diameter) Piping Welds | 25 |
| Small-Diameter Piping Welds | 20 |
| Control Rod Drive Mechanisms | 17 |
| Narrow-Gap Welds | 15 |
| Reactor Pressure Vessels | 14 |
| Piping Welds with Overlays | 14 |
| Piping Welds with Inlays | 13 |
| Reactor Internals | 9 |
| New Alloys | 9 |
| Piping Welds with Stress Mitigation Techniques | 8 |

### 3.2 Current Status of PARENT RRT

In PARENT kick off meeting on June 2010, there was a lot of discussion for international RRT program. We are still discussing how to make flaws in test blocks.

The PARENT decided 3 types of test blocks for RRT, such as BMI, 75cm (large) dia. DMW piping, and 15-30cm (small) dia. DMW piping. In case of small DMW, overlay test block may be used according to the Korea side request. On the other hand, the PARENT RRT will be performed by two tracks RRT. One is closed RRT such as blind test, the other is open RRT. The open RRT is used for emerging NDE techniques, which inspectors can obtain the flaw information.

Table 2 shows the preliminary summary for inspection techniques and teams proposed for open and closed testing. KINS will be a management organization and 5 domestic NDE teams will be participated in closed RRT. Some of universities have interest for open RRT to use their emerging NDE techniques.

Table 2 Preliminary Summary for PARENT RRT

| | | Test Blocks | | |
|---|---|---|---|---|
| | PARENT Participant | BMI | 75 cm Diameter DMW Piping | 15-30 cm Diameter DMW Piping |
| | | NDE Technique/Teams Proposed | | |
| OPEN | KINS - Korea | | Advanced Phased Array | |
| | VTT - Finland | | | Advanced Phased Array |
| | EPRI - USA | Array ECT | Array ECT, Filmless Radiography | Array ECT, Filmless Radiography |
| | ENSI - Switzerland | | | To Be Determined (15cm) |
| | Tohoko University - Japan | Advanced ECT and non-Linear UT | Advanced ECT and non-Linear UT | Advanced ECT and non-Linear UT |
| | To Be Determined - USA | To Be Determined | To Be Determined | To Be Determined |
| CLOSED | MHI/JNES - Japan | Possible Adaptive Phased Array UT, ECT 2 Teams | Posible Phased Array UT, ECT 2 Teams | Phased Array UT 1 Team |
| | KINS - Korea | 1 Team | 5 Teams | 2 Teams |
| | VTT - Finland | | | Advanced Phased Array 1 Team |
| | EPRI - USA | Possible Wesdyne and Olympus, Areva, ISI Southwest | Possible Wesdyne and Olympus, Areva, ISI Southwest | Possible Wesdyne and Olympus, Areva, ISI Southwest |

## 4. Summary

Following the PINC program, the new PARENT RRT program was launched this year. It will be an important international RRT for DMW reliability assessment in near term.

## Acknowledgements

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[1] 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)

[2] NRC Regulatory Issue Summary 2008-25, “Regulatory Approach for Primary Water Stress Corrosion Cracking of DMW in PWR system RCS piping.

[3] KNS Autumn Meeting 2009, “International RRT Results for DMW,” Sung-Sik Kang, et. al.