Conclusions to PINC Final Report

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Conclusions Modified Based on PINC 14

- The conclusions to the PINC Final report were originally assembled form the DMW and BMI reports.
- These conclusions were discussed and changes were made at the PINC 14 meeting in Washington D.C.
- This presentation contains the revised conclusions.

POD Performance for DMW Round Robin

8.1.1 Conclusion 1

Conclusion: Eddy current inspection demonstrated the highest probability of detection for all flaws in the DMW round robin.

Recommendation: The results of this study show that eddy current inspection should be the preferred detection technique for dissimilar metal welds, where inspection of the weld allows access to the same surface from which the crack originates.

POD Performance for DMW Round Robin

8.1.1 Conclusion 2

Conclusion: The POD results for the DMW round robin show significant variability in POD performance based upon technique, procedure, and team.

Recommendation: The results illustrate the need for performance demonstration as a means to help ensure the reliability of DMW inspections.

POD Performance for DMW Round Robin

8.1.1 Conclusion 3

Conclusion: The potential-drop techniques that were used in the DMW round robin demonstrated the lowest POD performance.

Recommendation: The potential-drop techniques used in the DMW round robin need further development for use as detection techniques in inservice inspection programs.

Bottom-Mounted Instrumentation Round Robin Probability of Detection Performance

8.1.2 Conclusion 1

Conclusions: Inspections using a single cross-coil eddy-current probe achieved a high POD and a low false call rate. These examinations were performed with multiple frequencies, with the highest frequency used being 300–400 kHz.

Recommendation: The results of this study suggest that single cross-coil probe eddy current using frequencies of 300–400 kHz should be the preferred method for finding surface breaking flaws in BMI J-groove welds.

Bottom-Mounted Instrumentation Round Robin Probability of Detection Performance

8.1.2 Conclusion 2

Conclusion: Inspections using adaptive phased array ultrasound were able to detect all baseline difficulty flaws and none of the challenging flaws (baseline and challenging flaws are defined in Section 4.2.2).

Recommendation: While adaptive phased array ultrasound was slightly less effective than eddy current testing, the results of this study suggest that adaptive phased array ultrasound can be effectively used to find flaws in BMI welds.

Bottom-Mounted Instrumentation Round Robin Probability of Detection Performance

8.1.2 Conclusion 3

Conclusion: The inspections using array eddy-current techniques used in this BMI round robin study had a reduced POD and a much higher false call rate compared to the higher frequency cross-coil ECT examinations.

Recommendation: The results of the BMI round-robin study show that the procedures using array ECT probes operating at 100–200 kHz used in this round robin test require further development for detection in inservice inspection programs.

Bottom-Mounted Instrumentation Round Robin Probability of Detection Performance

8.1.2 Conclusion 4

Conclusion: The closely coupled potential-drop technique was able to detect thermal fatigue flaws and SCC flaws with a POD of 50%. For weld solidification flaws, the POD was 0%. No false calls were made by the inspectors using this technique.

Recommendation: The results of the BMI round-robin study show that the closely coupled potential-drop technique requires further development before it can be used for detection of flaws in inservice inspection programs.

Bottom-Mounted Instrumentation Round Robin Probability of Detection Performance

8.1.2 Conclusion 5

Conclusion: Induced-current potential drop was used on only one baseline difficulty test block and two challenging test blocks, possibly skewing the results. There are not enough inspections on baseline difficulty test blocks to draw meaningful conclusions on the POD performance on these test blocks.

Recommendation: Further testing needs to be performed to determine if ICPD can be used for inservice inspection.

Dissimilar Metal Weld Pipe Specimen Sizing Performance

8.2.1 Conclusion 1

Conclusion: None of the NDE techniques in this round robin study demonstrated the capability to accurately depth size flaws in dissimilar metal welds to ASME Section XI code standards. The average depth sizing for all techniques tended to slightly undersize the flaws and had standard deviations and RMSE errors of approximately 7 mm. Two techniques came close to meeting ASME Section XI code standards.

Recommendation: The depth sizing of flaws should be improved. The use of phased array UT and conventional ultrasound together showed the most promise.

Dissimilar Metal Weld Pipe Specimen Sizing Performance

8.2.1 Conclusion 2

Conclusion: Eight teams length-sized flaws with an RMSE within the ASME Section XI standard of 0.75 inch (19 mm). Teams that used phased array UT and eddy current achieved higher accuracy than teams that used conventional UT and potential-drop techniques.

Recommendation: A combination of eddy-current techniques and conventional UT or phased array UT should be used for length sizing. Phased array UT can also perform as well for length sizing as eddy current from the outside of the pipe.

Bottom-Mounted Instrumentation Weld Sizing Performance

8.2.2 Conclusion 1

Conclusion: Cross-coil eddy current, adaptive phased array ultrasound, and closely coupled probe potential-drop techniques were able to accurately length-size the flaws in the J-groove welds (RMSE of 2.45-4.70 mm).

Recommendation: These techniques can be used to length-size flaws in BMI J-groove welds.

Bottom-Mounted Instrumentation Weld Sizing Performance

8.2.1 Conclusion 2

Conclusion: The test block geometry made depth-sizing using ultrasound difficult, and not enough data was collected in this round-robin test to accurately determine the effectiveness of the depth-sizing techniques.

Recommendation: More work should be performed to determine the depth-sizing capabilities of the various techniques.

Sizing Performance

Based on the round-robin tests, including detection and length-sizing capabilities, several techniques need to be used in tandem for adequate flaw detection and sizing in dissimilar metal welds. Eddy current was the only technique that provided adequate flaw detection from the ID, and a combination of conventional and phased array ultrasound was the only technique that provided adequate depth-sizing capabilities. Eddy current may be usable on its own if repairs or mitigation are to be applied on any SCC that is detected, regardless of flaw depth. It is worth noting that eddy current is not universally applicable for dissimilar metal welds, as many welds are in locations that do not allow for ID inspections. If ID access is not possible, a combination of phased array ultrasound and conventional ultrasound appears to be the most accurate alternative.

General Conclusions

8.3 Conclusion 1

Conclusion: The surface conditions, access to both sides of the weld, and inspection conditions for the PINC specimens provided the inspectors with less challenging conditions than would be expected in field inspections of nuclear power plant components.

Recommendations: The probability of detection and sizing results should be considered an upper boundary for the inspection techniques.

General Conclusions

8.3 Conclusion 2

Conclusion: Inspection procedures and teams with formal NDE qualifications tended to have a higher POD and lower false call rate than teams and procedures with no formal qualifications.

Recommendation: As NDE inspections are carried out by qualified inspectors, the probability of detection and length sizing results for the qualified teams and procedures should be considered the most representative of field inspections.

General Conclusions

8.3 Conclusion 3

Conclusion: An analysis of the POD curves generated by the PINC round robin testing showed that the procedures improved safety by factors of 1.1 to 1.5 for a 10 year interval and by factors of 1.3 to 2.1 for a four year interval. (These safety factors use the crack growth rates for stress corrosion cracks in stainless steel welds.)

Recommendation: For significant improvements in safety for components susceptible to PWSCC, effective NDE techniques may need to be combined with inspection intervals selected based on the crack growth rates. The analysis should be refined using PWSCC crack growth rates in nickel-based alloys.