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DUKE POWER

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: McGuire Nuclear Station
McGuire Nuclear Station, Unit 2
Docket No: 50-370
Section XI, Inservice Inspection
Reexamination of Reactor Vessel Planar Flaw

Dear Sir:

Please find enclosed the action plan that has been formulated to complete the 1st period flaw reexamination for the planar flaw discovered in the McGuire Nuclear Station Unit 2 Reactor Vessel during end-of-cycle 8.

The enclosed information consists of Attachment 1 which defines the history of the flaw, associated code requirements, and the action plan proper. Additionally, Enclosure 1 describes the protocol for demonstrating the performance of ultrasonic techniques for identification and sizing of outside diameter surface-connected flaws. Attachments A and B of Enclosure 1 outline the demonstration of the mock-ups and results respectively. Enclosure 2 visually depicts the action plan. This plan is submitted for NRC information.

Should there be any questions regarding this matter, please contact John M. Washam at (704) 875-4181.

Very truly yours,

T. C. McMeekin

A047 1/1

xc: Mr. S.D. Ebneter
Administrator, Region II
U.S. Nuclear Regulatory Commission
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Mr. Victor Nerses
U.S. Nuclear Regulatory Commission
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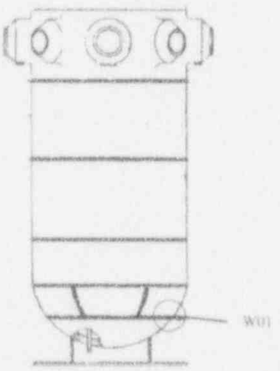
Mr. G.F. Maxwell
NRC Resident Inspector
McGuire Nuclear Station

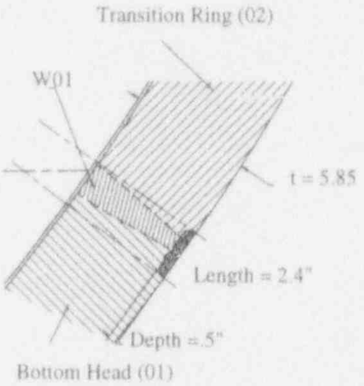
Purpose

To inform the NRC Staff of proposed reexamination methods required for the McGuire Unit 2 reactor vessel planar flaw discovered during refueling outage EOC8.

History

During the current end-of-cycle 8 (EOC 8) refueling outage for Unit 2, a longitudinal planar flaw was detected using ultrasonic examination at the lower head to ring segment girth weld (WOl) on the outer wall surface of the reactor vessel. The flaw was determined to have the configuration as shown:





This indication was determined to exceed the allowable flaw size for acceptance by volumetric examination as specified by IWB-3510.1, of the 1980 edition of the ASME Boiler and Pressure Vessel Code (the Code), Section XI. In such cases, the Code (IWB-3132.4) allows acceptance of the flaw indication by analytical evaluation. To this end, the indication was evaluated in accordance with the methods described in Appendix A of the Code and met the acceptance criteria specified by IWB-3600.

A review of the fabrication history determined that all fabrication inspections of the subject weld were completed by March of 1974, and the baseline radiograph of the weld was performed on January 21, and March 20, 1972. These records and a review of the radiography film showed no indications in this area. Due to activities related to the continued vessel fabrication, vessel shipping, site construction, and installation, it is possible that the cause for the indication occurred after these original inspections. Further, ultrasonic amplitude based flaw sizing techniques are likely to have determined this indication to be non-recordable, as explained in "Code Requirements".

The baseline ultrasonic examination was performed on September 8, 1978, during the preservice examination. As with the Section III examinations, the amplitude based flaw sizing techniques used for this initial Section XI examination are likely to have determined this indication to be non-recordable.

Duke Power's flaw evaluation concluded that the Unit 2 reactor vessel is acceptable for continued service for the licensed life of McGuire Nuclear Station, Unit 2 (March 3, 2023), and that the following standards were satisfied:

a) the criteria of IWB-3612;
b) the primary stress limits of NB-3000.

This evaluation also concluded that crack growth is bounded by 0.001" for licensed station life. Therefore detectable crack growth for this flaw is very unlikely.

Code Requirements

The ultrasonic flaw sizing techniques used by B&W Nuclear Service Company (BWNS) greatly exceed the requirements of the 1989 ASME Boiler and Pressure Vessel Code (the Code). Specifically, IWA-2232(a) requires examination in accordance with Article 4 of Section V of the Code. T-441.3.2.8(a) of Article 4 requires recording planar reflectors that exceed 20% of the distance-amplitude correction (DAC), but the flaw in question has a peak amplitude from all scans at only 16% of DAC. Per the Code, therefore, this flaw is technically NOT RECORDABLE. Due to the Nuclear Safety concern associated with reactor vessel flaws, BWNS elects to evaluate planar flaws of any amplitude rather than use the Code threshold.

T-441.3.2.8(c)(2) of Article 4 uses the minimum responses at 20% of DAC when approaching and moving away from the reflector as depth measurement and T-441.3.2.8(c)(3) uses the position of 20% of DAC responses as endpoints for length determination. Since no response exceeds 20%, the flaw technically has no depth or length per this method. Also, T-452.1 requires comparison of opposite surface reflectors to the surface calibration notch signals, where equal response may be considered as indicative of equal depth (2% t). Calibration records show the response from the 2% t reflector to average about 90% of DAC. Therefore amplitude based sizing would estimate this indication to be far smaller than .02 x 6" ≡ .1", and therefore not recordable.

BWNS, however, used a newer and generally more accurate backward scattering tip diffraction sizing technique to measure .5" depth. Further, BWNS evaluated all responses above background noise (versus the Code threshold) to determine the length of 2.4". This results in a greater estimated length than other amplitude based sizing techniques, such as 6 dB-drop, 50% DAC, or 20% DAC.

EPRI report NP-1406-SR, Nondestructive Examination Acceptance Standards, states that the intent of the Code Section XI surface flaw acceptance standard was "to ensure that the flaws accepted by the volumetric examination standards of ASME Code-Section XI would be as close as practical to the size of flaws accepted by the standards of ASME Code-Section III." By exceeding the sizing standards of Section III and Section XI, additional conservatism's are introduced that may cause previously accepted flaws to be evaluated as unacceptable. This is the most likely explanation for this flaw.

Duke Power is currently committed to performing flaw reexaminations required by IWB-3132.4(b) and in accordance with IWB-2420(b) and (c). The next three inspection periods of IWB-2420 (b) correspond to the following at McGuire:

Inspection Interval	Inspection Period	McGuire Outage	Activity
1st	10	EOC -8	Flaw discovered, 10 yr ISI
	13	EOC -9, or -10	1st Reinspection
	17	EOC -11, -12, or -13	2nd Reinspection
2nd	20	EOC-14	3rd Reinspection, 20 yr ISI

IWB-2420(c) allows reverting to the original 10 year examination schedule if the flaw indication remains essentially unchanged for three successive inspection periods.

Since the 1989 Code only considers 20% of DAC ultrasonic technique in flaw sizing, consistency between sizing techniques used for the flaw discovery and reinspections is not discussed. Duke Power intends to perform the 1st and 2nd reinspections using an external examination, as discussed in Enclosure 1. The 3rd reinspection will be performed internally in conjunction with the 20 year ISI. Since this flaw has been determined by fracture mechanics to have negligible growth potential for the remaining service life, the flaw size trending benefits obtained by using the same internal technique for all reinspections are small compared with the benefits of an external examination, which includes visual and magnetic particle examinations as well as a more accurate ultrasonic examination.

Action Plan

The following activities have been determined necessary to complete the 1st period flaw reexamination for the external surface of the reactor vessel (See Enclosure 2 for flow diagram):

1) Prior to Unit 2 EOC-9 Refueling Outage: (Start date: 11//94)
   a) Advise NRC Staff of 1st period reexamination plan from the external surface of the reactor vessel.
2) Examinations During Unit 2 EOC-9 Refueling Outage:
   a) Access the Incore Instrumentation Room and perform area radiation survey for dose assessments.
   b) Install access equipment for working within the mirror insulation support frame.
   c) Perform visual and video examination of the flaw area using preconstructed geometric guides to locate the flaw.
   d) Determine the suitability of the vessel surface for performance of magnetic particle examination. If necessary, some surface preparation may be performed.
   e) Perform magnetic particle examination of the flaw area and record result. This examination may be canceled if significant surface preparation is required.
   g) If the flaw cannot be located using the previous examination methods, a manual ultrasonic examination will be performed to located the flaw.
   h) Finally, an automatic ultrasonic will be performed for permanent record sizing.
3) Possible Examinations Results:
   a) The surface examinations may determine the flaw to be a fabrication discontinuity, gouge, or porosity. In this case Duke Power will pursue relief from further Code re-examinations.
   b) The ultrasonic examination may determine the flaw to be smaller due to closer proximity of the probe. If the flaw is sized smaller than Code allowable limits, Duke Power will pursue obtaining NRC concurrence to return to original 10 year inspections.
   c) If the flaw is "essentially unchanged", Duke Power will reexamine the flaw within the 2nd and 3rd reinspection periods. The 2nd re-examination will be external and the 3rd will be internal.
   d) In the unlikely event that the flaw indicates growth, Duke Power will determine an action plan at that time.
4) Flaw Repair Option:
   If later determined to be necessary or cost effective, Duke Power may develop a repair method in accordance with IWB-3132.2 to remove the flaw. The required minimum wall thickness in this region is 4.312" versus the actual wall thickness of 5.69", which allows an excess of 1.378".

Discussion of NDE Equivalence of Internal and External Examinations

Duke Power intends to use the most accurate ultrasonic technique currently available. Based on EPRI evaluation, the most accurate technique is Forward Scattering Tip Diffraction (TOFD). EPRI Report NP-6273, March 1989 summarizes the accuracies for the various ultrasonic techniques as:

Examination Technique	Mean Error in.	Std Deviation in.	RMS Error in.	Comments
TOFD	.016	.051	.051	Similar to proposed external exam
Backward scattering Tip-defraction	.035	.15	.15	Similar to ACCUSONEX (B&W)
6 dB-drop	.0039	.21	.21	N/A for McGuire RV
50% DAC	.12	.535	.547	N/A for McGuire RV
20% DAC	.31	.504	.594	Section III and Preservice ISI examinations

B&W documentation provides the following accuracy for their technique:

Examination Technique	Mean Error in.	Std Deviation in.	RMS Error in.	Comments
ACCUSONEX (B&W)	.0077	.1665	.1667	10 year ISI for depth

Enclosure 1 reports the efforts used to qualify the proposed external ultrasonic examination technique. This enclosure provides documentation of the following accuracy for the external inspection:

Examination Technique	Mean Error in.	Std Deviation in.	RMS Error in.	Comments
Duke Power TOFD	.06	.18	.06	Proposed for 1st & 2nd reinspections

Appendix VIII of Section XI of the 1992 Code, including 1993 Addenda, specifies ultrasonic examination performance demonstration acceptance criteria. Although this Code edition has not been adopted by the NRC, the industry intends to qualify all procedures, equipment, and personnel per Appendix VIII by 1996. For flaw sizing performance demonstration, the length dimension must be estimated within 1 inch of the true length and the depth measurement RMS Error must be less than or equal to 0.125 inch. RMS Error is calculated by:

$$\text{RMS Error} = \left[\frac{\sum_{i=1}^{n} (m_i - t_i)^2}{n} \right]^{1/2}$$

where:
m_i = measured flaw depth
t_i = true flaw depth
n = number of flaws sized

As documented above, only the EPRI TOFD and the Duke Power TOFD techniques currently have less than .125 inch RMS error. The Duke Power TOFD ultrasonic examination technique will provide flaw sizing information of similar accuracy as the original BWNS examination. This technique is therefore suitable for use to satisfy Duke Power's reexamination requirements per IWB-2420.

Summary

Duke Power intends to perform the 1st and 2nd reexaminations of the Unit 2 reactor vessel flaw from the external surface of the vessel. These examinations will provide better information for flaw characterization than is obtainable from the internal surface since we include visual and magnetic particle examinations. Further, the external method allows ultrasonic examination from both circumferential directions, versus the single direction for the internal method. The 3rd reexamination shall be performed from the internal surface in conjunction with the 2nd 10 year inservice inspection. This series of reexaminations is sufficient to determine if the flaw is "essentially unchanged" to allow returning to the normal 10 year inspection intervals.

ENCLOSURE 1

EPRI NDE CENTER

Electric Power Research Institute
Nondestructive Evaluation Center — *Leadership in Technology Transfer*

March 18, 1994

Jim McArdle
Duke Power Co.
Quality Assurance Dept.
P. O. Box 1006
Charlotte, NC 28201-1006

SUBJECT: Development and demonstration of ultrasonic techniques for characterization and sizing of Reactor Pressure Vessel O.D. Surface-connected flaws.

Dear Jim:

Enclosed are the results of the procedure development and demonstration project conducted at the NDE Center. A copy of the protocol, mock-up description (Attachment a) and demonstration results (Attachment b) are included.

As you will see by the linear regression analysis, the sizing results were very good. As we discussed, flaw characterization and tip identification will be greatly enhanced by incorporating a supplemental backward-scatter technique into your procedure.

As we discussed, we will be available to work with you during the examination of the McGuire RPV, if ultrasonic examination becomes necessary.

Please let me know if we can be of any further assistance.

Sincerely,

E. Kim Kietzman

E. Kim Kietzman
Supervisor
HSI Technology

EKK:inb
Attachment
cc: F. Ammirato
L. Becker
J. Lance
Tom Alley, Duke Power
Greg Robinson, Duke Power