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Summary of Weld Overlay Ultrasonic Examinations for Reactor Coolant Pump Suction and Discharge Nozzle Welds, Core Flood Nozzle Welds, and Cold Leg Drain Nozzle Welds at Davis-Besse Nuclear Power Station, Unit 1

Prepared for:

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Davis-Besse Nuclear Power Station
Project 0800368

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1.0 INTRODUCTION

FirstEnergy Nuclear Operating Company (FENOC) has applied preemptive full structural weld overlays (FSWOLs) and preemptive optimized weld overlays (OWOLs) at the Davis-Besse Nuclear Power Station (Davis-Besse) on Alloy 600 dissimilar metal welds (DMWs) of the components identified herein. The overlays eliminate or reduce the dependence upon the Alloy 82/182 welds as pressure boundary welds and mitigate any potential primary water stress corrosion cracking (PWSCC) in these welds in the future.

The requirements for design of weld overlay (WOL) repairs are defined in 10 CFR 50.55a Requests RR-A32 and RR-A33, with supplements [1-4], as approved in Nuclear Regulatory Commission (NRC) Safety Evaluations [5, 6]. The basis for FSWOLs is ASME Code Case N-740-2 [8], and for OWOLs the basis is Code Case N-740-2 [8] and MRP-169, Revision 1 [9].

This report, which satisfies FENOC Commitment No. 3 of the Relief Requests [1], summarizes the final post-implementation ultrasonic examinations performed on the Davis-Besse weld overlays. The examinations were performed using Structural Integrity's, ASME Code, Section XI [7], Appendix VIII, Supplement 11, PDI qualified ultrasonic examination procedures, equipment, and personnel. No unacceptable flaw indications were detected in the overlays or base metal, and no repairs were made to either the base metal or WOLs.

The summaries of the UT Reports include the coverage percentages for both axial and circumferential scanning. Although 100 percent coverage is desired, greater than 90 percent examination coverage is considered as "essentially 100 percent," as documented in ASME Code Case N-460 [10].

2.0 ULTRASONIC EXAMINATION PROCEDURE – SI-UT-126

SI-UT-126, Revision 3, *Procedure for the Phased Array Ultrasonic Examination of Weld Overlaid Similar and Dissimilar Metal Welds*, was used during the examinations. This procedure, equipment, and the personnel that applied the procedure, are qualified through the ASME Code, Section XI, Appendix VIII, Supplement 11, PDI program at the EPRI NDE Center.

2.1 Core Flood Nozzle (South) Weld Overlay Examination

Component Identification: Reactor Vessel Core Flood 1-1 (South) Nozzle
Full Structural Weld Overlay
ISI Component ID: RC-RPV-WR-53-Y, Nozzle-to-Safe End
Examination Date: 03/28/10 Examination Time: 05:20 – 06:30
ISI Report No.: DB Overlay RC-RPV-WR-53-Y Core Flood 1-1

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld
Axial Examination Angles: 0° through 84°; Circumferential Examination Angles: 0° through 69°

Examination Summary: Two flaw indications were detected during the examination, both of which were characterized as laminar flaws. Both laminar flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A33 [5]. The examination gain was adjusted to maintain the procedure-specified baseline noise level from 5 percent to 20 percent of full screen height. The lower range of examination angles detected responses from the inside surface of the component which were useful for monitoring search unit contact / coupling effectiveness during the examination. 100 percent axial scan and circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

2.2 Core Flood Nozzle (North) Weld Overlay Examination

Component Identification: Reactor Vessel Core Flood 1-2 (North) Nozzle
Full Structural Weld Overlay
ISI Component ID: RC-RPV-WR-53-W, Nozzle-to-Safe End
Examination Date: 03/29/10 Examination Time: 00:30 – 01:30
ISI Report No.: DB Overlay RC-RPV-WR-53-W Core Flood 1-2

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld
Axial Examination Angles: 0° through 84°; Circumferential Examination Angles: 0° through 69°

Examination Summary: One flaw indication was detected during the examination, which was characterized as a laminar flaw. The laminar flaw was determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A33 [5]. The examination gain was adjusted to maintain the procedure-specified baseline noise level from 5 percent to 20 percent of full screen height. The lower range of examination angles detected responses from the inside surface of the component which were useful for monitoring search unit contact / coupling effectiveness during the examination. 100 percent axial scan and circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

3.0 ULTRASONIC EXAMINATION PROCEDURE – SI-UT-145

SI-UT-145, Revision 0, *Procedure for the Manual Phased Array Ultrasonic Examination of Weld Overlaid Similar and Dissimilar Metal Piping Welds – EPRI-WOL-PA-1*, was used during the examinations. This procedure, equipment, and personnel that applied the procedure, are qualified through the ASME Code, Section XI, Appendix VIII, Supplement 11, PDI program at the EPRI NDE Center.

3.1 Cold Leg Drain Nozzle 1-2 Weld Overlay Examination

Component Identification: Cold Leg Drain 1-2 Nozzle Full Structural Weld Overlay
ISI Component ID: RC-40-CCA-18-3-FW9 Overlay, Nozzle-to-Elbow Weld
Examination Date: 04/1/10 Examination Time: 15:01 – 15:22
ISI Report No.: DB Drain 1-2 - WOL

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: 0° through 85°; Circumferential Examination Angles: 0° through 85°

Examination Summary: No suspected flaws were observed during the examinations. The examination gain was adjusted to maintain the procedure-specified baseline noise level from 5 percent to 20 percent of full screen height. 100 percent axial scan coverage and 80.1 percent circumferential scan coverage of the ASME Code Case N-740 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations. The less than 90 percent circumferential scan coverage was the result of the drain nozzle and attached elbow geometry. Specifically, the fitup of the elbow, and the resulting reduced intrados clearance, prevented interrogation of the inspection volume on the elbow side.

3.2 Cold Leg Drain Nozzle 2-1 Weld Overlay Examination

Component Identification: Cold Leg Drain 2-1 Nozzle Full Structural Weld Overlay
ISI Component ID: RC-40-CCA-18-7-FW25 Overlay, Nozzle-to-Elbow Weld
Examination Date: 03/11/10 Examination Time: 15:41 – 15:58
ISI Report No.: DB Drain 2-1 - WOL

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: 0° through 85°; Circumferential Examination Angles: 0° through 85°

Examination Summary: No suspected flaws were observed during the examinations. The examination gain was adjusted to maintain the procedure-specified baseline noise level from 5 percent to 20 percent of full screen height. 100 percent axial scan and circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

3.3 Cold Leg Drain Nozzle 2-2 Weld Overlay Examination

Component Identification: Cold Leg Drain 2-2 Nozzle Full Structural Weld Overlay
ISI Component ID: RC-40-CCA-18-5-FW18 Overlay, Nozzle-to-Elbow Weld
Examination Date: 03/15/10 Examination Time: 14:38 – 15:06
ISI Report No.: DB Drain 2-2 - WOL

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: 0° through 85°; Circumferential Examination Angles: 0° through 85°

Examination Summary: No suspected flaws were observed during the examinations. The examination gain was adjusted to maintain the procedure-specified baseline noise level from 5 percent to 20 percent of full screen height. 100 percent axial scan and circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

4.0 ULTRASONIC EXAMINATION PROCEDURE – SI-UT-149

SI-UT-149, Revision 3, *Procedure for the Automated Phased Array Ultrasonic Examination of Weld Overlaid Piping Welds*, was used during the examinations. This procedure, equipment, and personnel that applied the procedure, are qualified through the ASME Code, Section XI, Appendix VIII, Supplement 11, PDI program at the EPRI NDE Center.

4.1 Reactor Coolant Pump 1-1 Suction Nozzle Full Structural Weld Overlay Examination

Component Identification: Reactor Coolant Pump 1-1 Suction Nozzle Full Structural Weld Overlay
ISI Component ID: RC-MK-B-67-1-FW134B, Elbow-to-Nozzle
Examination Date/Time: 04/12/10 19:27 – 4/14/10 01:52
ISI Report No.: DB Overlay RC-MK-B-67-1-FW134B Suction 1-1

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, seven flaws were detected. One flaw was characterized as being laminar and six flaws were characterized as being planar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, ASME IWB-3514 [7] and the Davis-Besse Relief Request RR-A33 [5]. 98.0 percent axial scan coverage and 95.2 percent circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

4.2 Reactor Coolant Pump 1-2 Suction Nozzle Full Structural Weld Overlay Examination

Component Identification: Reactor Coolant Pump 1-2 Suction Nozzle Full Structural Weld Overlay
ISI Component ID: RC-MK-A-67-3-FW105B, Elbow-to-Nozzle
Examination Date/Time: 04/14/10 21:30 – 4/15/10 03:15
ISI Report No.: DB Overlay RC-MK-A-67-3-FW105B Suction 1-2

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, seven flaws were detected. All flaws were characterized as being laminar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A33 [5]. 93.8 percent axial scan coverage and 94.2 percent circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

4.3 Reactor Coolant Pump 2-1 Suction Nozzle Full Structural Weld Overlay Examination

Component Identification: Reactor Coolant Pump 2-1 Suction Nozzle Full Structural Weld Overlay
ISI Component ID: RC-MK-A-67-1-FW105A, Elbow-to-Nozzle
Examination Date/Time: 04/2/10 16:50 – 4/3/10 00:30
ISI Report No.: DB Overlay RC-MK-A-67-1-FW105A Suction 2-1

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, three flaws were detected. All flaws were characterized as being laminar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A33 [5]. 100.0 percent axial scan coverage and 94.6 percent circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

4.4 Reactor Coolant Pump 2-2 Suction Nozzle Full Structural Weld Overlay Examination

Component Identification: Reactor Coolant Pump 2-2 Suction Nozzle Full Structural Weld Overlay
ISI Component ID: RC-MK-A-67-2-FW134A, Elbow-to-Nozzle
Examination Date/Time: 03/30/10 17:35 – 3/31/10 01:20
ISI Report No.: DB Overlay RC-MK-A-67-2-FW134A Suction 2-2

Weld Overlay Regions: Overlay, Weld and Base Material (Outer 25 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, no flaws were detected. 100.0 percent axial scan coverage and 98.4 percent circumferential scan coverage of the ASME Code Case N-740-2 [8] required examination volume, as documented in the Relief Request [5], was achieved during the examinations.

4.5 Reactor Coolant Pump 1-1 Discharge Nozzle Optimized Weld Overlay Examination

Component Identification: Reactor Coolant Pump 1-1 Discharge Nozzle Optimized Weld Overlay
ISI Component ID: RC-MK-B-59-1-SW143B, Elbow-to-Safe End
Examination Date/Time: 04/14/10 08:39 – 19:41
ISI Report No.: DB Overlay RC-MK-B-59-1-SW143B Discharge 1-1

Weld Overlay Regions: Overlay, Weld and Base Material (Axial Flaws – Outer 25 percent, Circumferential Flaws - Outer 50 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, four flaws were detected. One flaw was characterized as being laminar and three flaws were characterized as being planar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A32 [6]. 98.6 percent axial scan coverage and 92.0 percent circumferential scan coverage of the MRP-169 [9] required examination volume, as documented in the Relief Request [6], was achieved during the examinations.

4.6 Reactor Coolant Pump 1-2 Discharge Nozzle Optimized Weld Overlay Examination

Component Identification: Reactor Coolant Pump 1-2 Discharge Nozzle Optimized Weld Overlay
ISI Component ID: RC-MK-B-44-1-SW69B, Elbow-to-Safe End
Examination Date/Time: 04/10/10 15:51 to 23:00
ISI Report No.: DB Overlay RC-MK-B-44-1-SW69B Discharge 1-2

Weld Overlay Regions: Overlay, Weld and Base Material (Axial Flaws – Outer 25 percent, Circumferential Flaws - Outer 50 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, three flaws were detected. All flaws were characterized as being planar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A32 [6]. 99.5 percent axial scan coverage and 100.0 percent circumferential scan coverage of the MRP-169 [9] required examination volume, as documented in the Relief Request [6], was achieved during the examinations.

4.7 Reactor Coolant Pump 2-1 Discharge Nozzle Optimized Weld Overlay Examination

Component Identification: Reactor Coolant Pump 2-1 Discharge Nozzle Optimized Weld Overlay
ISI Component ID: RC-MK-B-61-1-SW69A, Elbow-to-Safe End
Examination Date/Time: 03/22/10 16:34 – 3/23/10 00:32
ISI Report No.: DB Overlay RC-MK-B-61-1-SW69A Discharge 2-1

Weld Overlay Regions: Overlay, Weld and Base Material (Axial Flaws – Outer 25 percent, Circumferential Flaws - Outer 50 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, four flaws were detected. Two flaws were characterized as being laminar and two flaws were characterized as being planar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A32 [6]. 98.9 percent axial scan coverage and 100.0 percent circumferential scan coverage of the MRP-169 [9] required examination volume, as documented in the Relief Request [6], was achieved during the examinations.

4.8 Reactor Coolant Pump 2-2 Discharge Nozzle Optimized Weld Overlay Examination

Component Identification: Reactor Coolant Pump 2-2 Discharge Nozzle Optimized Weld Overlay
ISI Component ID: RC-MK-B-56-1-SW143A, Elbow-to-Safe End
Examination Date/Time: 03/24/10 11:30 – 3/25/10 00:19
ISI Report No.: DB Overlay RC-MK-B-56-1-SW143A Discharge 2-2

Weld Overlay Regions: Overlay, Weld and Base Material (Axial Flaws – Outer 25 percent, Circumferential Flaws - Outer 50 percent) Dissimilar Metal Weld

Axial Examination Angles: -10°, 0°, 10°, 25°, 35°, 45°, 55°, 65°, and 75°

Circumferential Examination Angles: 25°, 35°, 45°, 55°, and 65°

Examination Summary: During the examination, two flaws were detected. One flaw was characterized as being laminar and one flaw was characterized as being planar. All flaws were determined to be acceptable in accordance with both ASME Code, Section XI, IWB-3514 [7] and the Davis-Besse Relief Request RR-A32 [6]. 99.45 percent axial scan coverage and 100.0 percent circumferential scan coverage of the MRP-169 [9] required examination volume, as documented in the Relief Request [6], was achieved during the examinations.

5.0 REFERENCES

1. FENOC Letter to Nuclear Regulatory Commission (NRC), 10 CFR 50.55a Requests for Alternative Dissimilar Metal Weld Repair Methods for Reactor Vessel Nozzles, Reactor Coolant Pump Nozzles, and Reactor Coolant Piping, January 30, 2009, L-09-020. [ADAMS Accession No. ML090350070]

2. FENOC Letter to NRC, Response to Requests for Additional Information Related to Alternative Dissimilar Metal Weld Repair Methods, July 13, 2009, L-09-179. [ADAMS Accession No. ML091950627]

3. FENOC Letter to NRC, Response to Requests for Additional Information Related to Alternative Dissimilar Metal Weld Repair Methods, November 23, 2009, L-09-268. [ADAMS Accession No. ML093360333]

4. FENOC Electronic Mail to NRC, Relief Requests A-32 and A-33, December 15, 2009. [ADAMS Accession No. ML100040016]

5. NRC Letter to FENOC, Davis-Besse Nuclear Power Station, Unit 1 – Relief Request RR-A33 for the Application of Full Structural Weld Overlays on Dissimilar Metal Welds of Reactor Coolant Piping, January 21, 2010. [ADAMS Accession No. ML100080573]

6. NRC Letter to FENOC, Davis-Besse Nuclear Power Station, Unit 1 – Relief Request RR-A32 for the Application of Full Structural Weld Overlays on Dissimilar Metal Welds of Reactor Coolant Piping, January 29, 2010. [ADAMS Accession No. ML100271531]

7. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, 1995 Edition through 1996 Addenda.

8. ASME Code Case N-740-2, "Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items."

9. Electric Power Research Institute (EPRI), "Materials Reliability Program: Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)," Revision 1, EPRI, Palo Alto, CA; and Structural Integrity Associates, Inc., San Jose, CA; 1016602, June 2008.

10. ASME Code Case N-460, "Alternate Examination Coverage for Class 1 and Class 2 Welds" Section XI, Division 1.