



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

June 10, 2013

Mr. Michael J. Pacilio  
President and Chief Nuclear Officer  
Exelon Nuclear  
4300 Winfield Road  
Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 - PROPOSED  
ALTERNATIVE RR-12-02 REGARDING WELD OVERLAY OF THE LOWER  
COLD LEG LETDOWN NOZZLE DISSIMILAR METAL WELDS AND ALLOY 600  
SAFE-END (TAC NO. ME9818)

Dear Mr. Pacilio:

By letter dated October 18, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12292A584), supplemented by letters dated January 17, 2013 (ADAMS Accession No. ML13018A248), and March 11, 2013 (ADAMS Accession No. ML13071A093), Exelon Generation Company, LLC (the licensee) submitted proposed alternative request RR-12-02 for the use of an alternative to certain requirements of the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code), Section XI, 2004 Edition, no Addenda, at Three Mile Island, Unit 1 (TMI-1). Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 55a(a)(3)(i), RR-12-02 proposes to install a full structural weld overlay as an alternate repair technique for the lower cold leg letdown nozzle dissimilar metal welds and Alloy 600 safe-end.

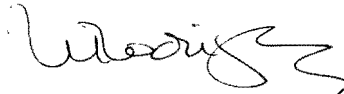
The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the proposed alternative as discussed in the enclosed safety evaluation. The NRC staff review concludes that the proposed alternative provides an acceptable level of quality and safety. Therefore, RR-12-02 is authorized pursuant to 10 CFR 50.55a(a)(3)(i). The design and installation aspects of the weld overlay are authorized for the remaining life of the components, including plant life extension. The inspection requirements proposed in RR-12-02 are authorized for the fourth 10-year inservice inspection interval. The fourth 10-year interval at TMI-1 will conclude on April 19, 2022. Certain inspection requirements of the overlay were previously authorized by NRC letter dated July 20, 2011 (ADAMS Accession No. ML111730475), in proposed alternative I4R-05, for the fourth 10-year inservice inspection interval at TMI-1. The NRC staff also notes that the inspection requirements, as mandated in 10 CFR 50.55a(g)(6)(ii)(F), are applicable to the future inservice inspection of the overlaid dissimilar metal welds and safe-end.

M. Pacilio

- 2 -

If you have any questions, please contact the TMI-1 Project Manager, Mr. Peter J. Bamford, at 301-415-2833.

Sincerely,

A handwritten signature in black ink, appearing to read "Veronica Rodriguez", with a long, wavy flourish extending to the right.

Veronica Rodriguez, Acting Chief  
Plant Licensing Branch I-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosure:  
Safety Evaluation

cc w/encl: Distribution via ListServ



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
PROPOSED ALTERNATIVE REGARDING WELD OVERLAY OF THE LOWER COLD LEG  
LETDOWN NOZZLE DISSIMILAR METAL WELDS AND ALLOY 600 SAFE-END

REQUEST NO. RR-12-02

EXELON GENERATION COMPANY, LLC

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

DOCKET NO. 50-289

1.0 INTRODUCTION

By letter dated October 18, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12292A584), supplemented by letters dated January 17, 2013 (ADAMS Accession No. ML13018A248), and March 11, 2013 (ADAMS Accession No. ML13071A093), Exelon Generation Company, LLC (the licensee) submitted proposed alternative request RR-12-02 for the use of an alternative to certain requirements of the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code), Section XI, 2004 Edition, no Addenda, at Three Mile Island, Unit 1 (TMI-1). Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 55a(a)(3)(i), RR-12-02 proposes to install a full structural weld overlay (FSWOL) as an alternate repair technique for the lower cold leg letdown nozzle dissimilar metal welds (DMWs) and Alloy 600 safe-end.

A DMW is a weld that joins two pieces of metal that are not of the same material. The DMW is made of nickel-based Alloy 82/182 material, which is susceptible to primary water stress-corrosion cracking (PWSCC) in the pressurized-water reactor (PWR) environment. The weld overlay is a process by which a PWSCC-resistant weld metal is deposited on the outside surface of the Alloy 82/182 DMWs to form a new pressure boundary.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical, within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the

Enclosure

requirements in the latest edition and addenda of Section XI of the ASME Code, incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

Pursuant to 10 CFR 50.55a(a)(3), alternatives to ASME Code requirements may be authorized by the Nuclear Regulatory Commission (NRC) if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request, and the NRC staff to authorize, the alternative requested by the licensee.

The Code of Record for the fourth 10-year ISI interval at TMI-1 is the 2004 Edition with no Addenda of the ASME Code, Section XI. The fourth 10-year interval began on April 20, 2011, and concludes on April 19, 2022, including the one year extension allowed by paragraph IWA-2430(d)(1) of ASME Section XI.

### 3.0 TECHNICAL EVALUATION

#### 3.1 ASME Code Component(s) Affected

The licensee stated that the affected components are safe-end to nozzle weld, MU-394BM, and elbow to safe-end weld, MU-395BM, of the 'C' Cold Leg Letdown piping. The welds are ASME Code Class 1. The Nominal Pipe Size (NPS) is 2½ inches and the nominal wall thickness is 0.375 inches.

The nozzle is made of carbon steel (P-No. 1). The safe-end and welds MU-394BM and MU-395BM are made of nickel-based alloy (P-No. 43). The elbow is made of stainless steel (P-No. 8). The examination category of these components is based on ASME Code Case N-722-1 and N-770-1, as conditioned in 10 CFR 50.55a(g)(6)(ii)(E) and (F), respectively.

#### 3.2 Licensee's Proposed Alternative

The licensee proposes to apply a preemptive FSWOL to the 'C' lower cold leg letdown nozzle safe-end to nozzle DMW, Alloy 600 safe-end, and elbow to safe-end DMW. The licensee plans to install the FSWOL during the refueling outage in fall 2013 (T1R20). The licensee's installation plan for the weld overlay includes a weld configuration that is conducive for ultrasonic (UT) examination of the DMWs in accordance with Code Case N-770-1.<sup>1</sup> The licensee stated that the current configuration allows no coverage for circumferential flaws and 37.6 percent coverage for axial flaws on the safe-end to elbow DMW.

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1 ASME Code Case N-770-1, "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated With UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities, Section XI, Division 1." ASME Code Case N-770-1 is conditioned by 10 CFR 50.55a(g)(6)(ii)(F).

The licensee stated that FSWOLs have been used for several years on piping of both Boiling-Water Reactor (BWR) and PWR components to arrest the growth of existing flaws while establishing a new structural pressure boundary. Currently, there are no generically accepted criteria for a licensee to apply a FSWOL onto Alloy 82/182 DMWs. ASME Code Section XI, 2004 Edition, no Addenda is applicable for the TMI-1 Section XI Repair/Replacement Program, but does not contain the needed requirements for FSWOLs. FSWOLs have been applied to DMWs in other components in the PWR industry. The licensee proposes to use the guidance of ASME Section XI Code Case N-740-2,<sup>2</sup> for application of a FSWOL to the lower cold leg letdown nozzle safe-end to nozzle DMW, Alloy 600 safe-end, and elbow to safe-end DMW at TMI-1.

The licensee proposes that final UT examination of the finished FSWOL will be performed using Electric Power Research Institute (EPRI) Performance Demonstration Initiative (PDI) demonstrated UT examination procedures and personnel in lieu of ASME Section XI, Appendix VIII, Supplement 11. The use of the PDI examination program was proposed by the licensee in alternative I4R-05, and was approved by the NRC by letter dated July 20, 2011 (ADAMS Accession No. ML111730475), for the fourth ISI interval at TMI-1.

The licensee stated that Code Case N-740-2 has been used as a basis for applying FSWOLs at other PWR plants. The letdown nozzle FSWOL will extend around the full circumference of the DMWs and safe-end as required by Code Case N-740-2. The licensee will determine the specific thickness and length according to the guidance provided in Code Case N-740-2. The licensee stated that the FSWOL will completely cover the DMWs and Alloy 600 safe-end and will also cover the necessary adjacent ferritic steel nozzle and stainless steel elbow base material with Alloy 52M material to the extent that PWSCC susceptible material is mitigated and examination capability is maintained for adjacent welds. The licensee stated that the purpose for this FSWOL approach is to produce a single FSWOL covering both DMWs thereby also providing the weld geometry required to perform the final UT examination and obtaining the necessary examination volume coverage.

Prior to installation of the FSWOL, in accordance with 10 CFR 50.55a(g)(6)(ii)(E), the licensee will complete a bare metal visual examination of the nozzle to safe-end and safe-end to elbow DMWs after the insulation is removed in the area around the nozzle and DMW areas to ensure that no through-wall (TW) cracks exist prior to applying the FSWOL. The licensee will not perform UT examinations in accordance with 10 CFR 50.55a(g)(6)(ii)(F) prior to performing the FSWOL. The licensee stated that this approach will result in the welds affected by this FSWOL being classified as inspection Item F per Code Case N-770-1 after installation of the FSWOL. The licensee will examine the completed FSWOL during the 2013 refueling outage as required by Code Cases N-740-2 and N-770-1 (as conditioned by 10 CFR 50.55a(g)(6)(ii)(F)). The licensee will perform subsequent UT examinations, as required by Code Case N-770-1, as conditioned by 10 CFR 50.55a(g)(6)(ii)(F) or other requirements approved by the NRC. The proposed alternative I4R-05, previously approved for use at TMI-1, addresses ASME Section XI, Appendix VIII, Supplement 11 qualification requirements for examination of FSWOLs using

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

the PDI program examination procedures. This alternative is applicable to existing and future structural weld overlays and is applicable to all fourth ISI interval examinations on this weld overlay.

The licensee stated that it will perform preservice UT examination to the maximum extent practicable for searching for axial and circumferential flaws. Based upon the currently understood configuration and design, the licensee anticipates 100 percent UT examination coverage in both circumferential directions searching for axially oriented flaws. Additionally, 100 percent UT examination coverage is anticipated in the downstream-oriented axial scan direction searching for circumferential flaws. The licensee indicated that the geometry of the stainless steel elbow limits UT examination coverage at the intrados of the elbow which results in a reduction of coverage. Therefore, the licensee stated that UT examination scans in the upstream axial direction, searching for circumferential flaws in the axial scan are expected to achieve approximately 93 percent coverage. This coverage (axial scan) will not interrogate 100 percent of the susceptible material volume in one of the four directions in the intrados region. The combined coverage for all four examination directions is expected to be approximately 98 percent because of the inherent scan limitation of the elbow. However, depending on actual final conditions, UT examination coverage may be less than 98 percent, but it is still expected to at least be greater than 90 percent.

Per Code Case N-740-2, Paragraph 1.2(d), prior to FSWOL application, the licensee will perform a liquid penetrant (PT) examination of the area where welding will occur, with the acceptance criteria that no indication with a major dimension greater than 1/16 inch is permitted. The licensee will remove or reduce rejectable indications to within the acceptance criteria, and perform the PT examination again. If any indication(s) do require repair, the licensee will complete the repair and perform PT on the repair area for final acceptance. In the application dated October 18, 2012, the licensee stated that:

TMI-1 intends to perform additional PT examination of the base metal/FSWOL as follows:

- On the base metal and existing DMWs after surface conditioning but prior to installing the FSWOL.
- After excavation of any unacceptable flaws.
- On the final FSWOL.
- After grinding on unacceptable indications.
- After completed repairs.

The licensee will perform UT examination of the completed FSWOL and after completing any repairs (if necessary) to the FSWOL. The licensee will provide the NRC with the results of the UT examination of the FSWOL within 30 days after the completion of the last UT examination of the FSWOL during the fall 2013 T1R20 refueling outage. In the letter dated January 17, 2013, the licensee submitted the supporting design analyses for the FSWOL to the NRC staff for review.

The licensee's design analysis included the following aspects of the FSWOL design:

- FSWOL structural sizing based on the maximum observed or assumed defect. Assumed flaw size is 100 percent TW circumferential flaw for the entire circumference and a 100 percent TW axial flaw that extends the combined length of the Alloy 82 DMWs and Alloy 600 safe-end.
- Design loads.
- A finite element model of the nozzle and associated components.
- Residual stress analysis that includes consideration of a severe inside diameter repair (assumed to be 50 percent TW, and 100 percent around the circumference, from the inside surface).
- ASME Code, Section III evaluation of the final configuration.
- Crack growth evaluation that uses a conservative flaw growth rate and either assumes an existing detected flaw size or assumed flaw size (75 percent TW in both axial and circumferential directions), whichever is greater.
- Effects of the FSWOL on the adjacent piping system.

The licensee will use a mechanized Gas Tungsten Arc Welding (GTAW) process and the ambient temperature temper bead method with ERNiCrFe-7A (referred to as Alloy 52M) weld metal. The licensee stated that when temper bead welding is not required, manual GTAW with Alloy 52M is an acceptable alternative to the mechanized GTAW for local repairs of weld defects or if additional weld metal is required locally to form the final FSWOL contour. The licensee will use shielded metal arc welding (SMAW) using Alloy 152 (ENiCrFe-7), or GTAW using Alloy 82 (ERNiCr-3), only to repair indications in the existing DMWs prior to FSWOL installation. The licensee will use Alloy 82 (ERNiCr-3) for a small segment of the sulfur mitigation layer to bridge between the stainless steel elbow and existing Alloy 82 DMW.

The licensee explained that monitoring of preheat and interpass temperature is necessary to assure the field welding heat input remains within qualified parameters. The licensee will monitor weld preheat temperature and heat input using calibrated contact pyrometers. The licensee will measure the interpass temperature multiple times within each layer. The licensee intends to install one or more sulfur mitigation layer(s) to prevent hot cracking of the Alloy 52M material due while welding on existing stainless steel materials. The licensee is aware of industry hot cracking that has been observed when welding Alloy 52M over a stainless steel material. In order to minimize the potential for cracking during installation of the letdown nozzle FSWOL at TMI-1, the licensee has established criteria and parameters for control of the welding process. As an example, the licensee has determined welding heat input range to minimize weld metal contamination from the existing elbow materials.

The FSWOL design includes no welding on cast stainless steel material, as the elbow construction is of wrought materials. Additionally, the licensee has reviewed the elbow

chemistries (from the Certified Material Test Report data) and weld geometry to determine the level of risk for hot cracking when welding Alloy 52M over stainless steel base material. This review will result in specific mitigation efforts that will be employed during the installation of the FSWOL. The licensee will implement weld parameters and techniques specially developed for welding over stainless steel and Alloy 82 DMWs to prevent cracking.

In the January 17, 2013, letter, the licensee clarified that the design and installation of the FSWOL are applicable to the current fourth ISI interval and the remaining service life of the plant. The fourth ISI interval began on April 20, 2011, and will conclude on April 19, 2022.

The licensee will schedule and perform subsequent inservice examinations in accordance with schedules and technical requirements acceptable to the NRC as discussed in 10 CFR 50.55a(g)(6)(ii)(F).

### 3.3 NRC Staff Evaluation

#### 3.3.1 General Discussion

The NRC staff has not approved ASME Code Case N-740-2; therefore, it uses the following documents to evaluate Relief Request RR-12-02:

The NRC staff used Code Case N-504-4, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1," which is conditionally accepted in Regulatory Guide (RG) 1.147, Revision 16, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1." As a condition of NRC approval, the ASME Code, Section XI, Appendix Q, "Weld Overlay Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping Weldments," shall be used when Code Case N-504-4 is used as documented in RG 1.147, Revision 16.

The NRC staff used Code Case N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique Section XI, Division 1," which is conditionally accepted in RG 1.147, Revision 16.

The NRC staff used Code Case N-770-1 as conditioned in 10 CFR 50.55a(g)(6)(II)(F). The NRC staff notes that the preservice and inservice examination requirements in Code Case N-770-1 are consistent with that of Code Case N-740-2.

The NRC staff used Electric Power Research Institute topical report, "Material Reliability Program (MRP): Technical Basis For Preemptive Weld Overlays For Alloy 82/182 Butt Welds in Pressurized Water Reactors (MRP-169), Revision 1," which the NRC approved in a letter dated August 9, 2010 (ADAMS Accession No. ML101660468). MRP-169, provides guidance and technical basis of the weld overlay design and analyses.

The authorization of this proposed alternative does not imply or infer the approval of ASME Code Case N-740-2. However, the NRC has previously approved relief requests that include and adopt provisions of Code Case N-740-2 as part of proposed alternative. By letter dated January 17, 2013, the licensee provided and included provisions of ASME Code Case N-740-2 as part of its proposed alternative. The licensee will apply the code case in its entirety to the



subject weld overlay with two exceptions:

- (1) Final UT examination of the finished FSWOL will be performed using EPRI PDI demonstrated UT examination procedures and personnel in lieu of ASME Section XI, Appendix VIII, Supplement 11, as discussed in the TMI-1 Relief Request I4R-05. That relief request addressed ASME Section XI, Appendix VIII, Supplement 11 qualification requirements for examination of FSWOLs and is applicable to existing and future structural weld overlays and all fourth 10-year ISI interval examinations on this weld overlay.
- (2) The geometry of the stainless steel elbow limits UT coverage at the intrados of the elbow which results in less than 100 percent coverage.

The NRC staff evaluation of the proposed alternative, including these exceptions, is described below.

### 3.3.2 Design Analysis

By letter dated January 17, 2013, the licensee supplemented the application dated October 18, 2012, with its weld residual stress analysis, crack growth analysis, weld overlay sizing calculation, and ASME Section III stress analysis for the FSWOL design. By letter dated March 11, 2013, the licensee provided updated analyses correcting proprietary markings in several of these analyses. The technical content of the analyses did not change between the two supplements.

#### 3.3.2.1 Weld Residual Stress Analysis

The licensee developed a finite element model to analyze the weld residual stress. The finite element model simulated the DMW, MU-394BM, joining the safe-end to the letdown nozzle and the second DMW, MU-395BM, joining the safe-end to the elbow. The model included cycles from an ambient condition to a steady state operating condition and a return to an ambient condition. The model also simulated a repair of a 50 percent through wall flaw connected to the inside surface of the DMW. The NRC staff finds that a 50 percent through-wall flaw repair is acceptable because this assumption would generate an appropriate weld residual stress in the DMWs.

As described in the supplement dated January 17, 2013, the licensee identified an error in one of its calculations. It used the material properties of low alloy steel for the cold leg, which is made of carbon steel. The licensee stated that the error does not affect the outcome of the analysis. The NRC staff finds that using the wrong material properties in the analysis, although not desirable, would not significantly affect the overlaid DMWs because the FSWOL design contains sufficient margin to maintain the structural integrity of the overlaid DMW, as evidenced by the weld overlay thickness which is about 80 percent of the pipe wall thickness.

The NRC staff reviewed the residual stress analysis and finds that the licensee has demonstrated that the FSWOL will generate the favorable compressive stresses at the inside surface of the DMWs and safe-end to minimize crack initiation and propagation at the inside surface of the DMWs and safe-end.

### 3.3.2.2 Crack Growth Analysis

The proposed alternative requires that a crack growth analysis be performed. The licensee's crack growth analysis postulated: (a) an inside surface-connected, partial through-wall, 360 degree circumferential flaw in a cylinder, and (b) an inside surface-connected, partial through-wall, semi-elliptical axial flaw to exist at the time the overlay is applied. The initial flaw depths for the circumferential and axial flaws are postulated to be 75 percent of the thickness of the original welds from the inside surface.

For the postulated flaws, the licensee calculated flaw growth based on PWSCC and fatigue degradation mechanisms. PWSCC growth is calculated using the Alloy 82/182 crack growth rate from MRP-115, "Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds." The licensee performed the fatigue crack growth analysis in the weld overlay if the postulated flaws grow through the original DMWs before the remaining service life of 22 years is reached. The licensee used applied stresses from both transient and sustained normal operating loads. The results from the crack growth calculation show that the final flaw depth after 22 years of service is less than the allowable flaw depth in accordance with the ASME Code, Section XI, acceptance criteria.

The NRC staff finds that the licensee postulated an initial flaw size in the axial and circumferential direction that is consistent with MRP-169, Revision 1, and, therefore, the postulated flaw size is acceptable. The licensee assumed fatigue is the degradation mechanism and not PWSCC for a flaw that may be propagated into the weld overlay from the DMW. The licensee's underlining assumption was that Alloy 52 weld metal used for the FSWOL is resistant to PWSCC; therefore, PWSCC degradation mechanism needs not to be considered for the flaw growth calculation in the weld overlay. The NRC and industry are currently performing research in PWSCC growth in Alloy 52 material. The preliminary results show that PWSCC may occur in Alloy 52 weld metal under certain conditions, although crack growth rate in Alloy 52 material is slower than in Alloy 82/182 material. Based on the slow growth rate in Alloy 52 material, the NRC staff finds that the licensee's assumption of a fatigue crack degradation mechanism is acceptable. Further, as proposed, the proposed alternative and Code Case N-770-1 require the subject DMWs to be re-inspected periodically. Thus, there is reasonable assurance of the structural integrity of the overlay because the specified inspections will allow for appropriate corrective action to be taken, if required.

### 3.3.2.3 Weld Overlay Sizing Analysis

The licensee designed the FSWOL sizing based on the assumed flaw size of 100 percent through-wall circumferential flaw for the entire circumference and a 100 percent through-wall axial flaw. The FSWOL length extends the combined length of the two DMWs and Alloy 600 safe-end. In the letter dated January 17, 2013, the licensee stated that the FSWOL thickness will be 0.30 inches minimum and 0.54 inches maximum, except at the elbow to safe-end transition where the thickness will be greater due to the FSWOL geometry required to facilitate UT examinations.

### 3.3.2.4 ASME Section III Analysis

The licensee analyzed the effects of the FSWOL on the adjacent piping system in accordance with the requirements of the ASME Code, Section III. The NRC staff reviewed the submitted analysis and finds that the overlaid letdown nozzle configuration satisfies the primary, primary plus secondary stress requirements, and the criteria for fatigue in accordance with the ASME Code, Section III. The NRC staff finds that the maximum primary plus secondary, membrane plus bending stress intensity ranges and fatigue usage factors for the letdown nozzle are all within the allowable of the ASME Code, Section III.

### 3.3.2.5 Design Analysis Section Conclusion

The NRC staff finds that the above analyses are consistent with MRP-169, Revision 1, and therefore, are acceptable.

### 3.3.3 Welding

The licensee will use the ambient temperature temper bead welding as specified in Mandatory Appendix I of Code Case N-740-2 when applying weld metal on the carbon steel nozzle. Appendix I is an earlier version of ASME Code Case N-638-4. The NRC staff finds that the requirements in Mandatory Appendix I are consistent with the requirements in Code Case N-638-4; therefore, Appendix I of Code Case N-740-2 is acceptable for use.

Section 5.0 of the relief request discusses the installation of one sulfur mitigation layer to prevent hot cracking on the stainless steel piping prior to depositing Alloy 52 weld material. The NRC staff asked the licensee to discuss whether the delta ferrite number of this mitigation layer satisfies the delta ferrite requirements of paragraph (e) in Code Case N-504-4.

By letter dated January 17, 2013, the licensee responded that the weld filler material for the sulfur mitigation layer will be ER309L stainless steel that produced a 9 FN [ferrite number] during vendor testing. The licensee expects that the as-deposited ferrite number will be at least 7.5 FN. The licensee stated that the ER309L weld metal improves Alloy 52M weldability by minimizing the potential of hot cracking from contaminants (i.e., sulfur, phosphorous, etc.) in the underlying stainless steel base material. The licensee further stated that because no structural credit is taken for the ER309L applied weld material, the minimum FN specified in Code Cases N-504-4 (paragraph (e)) and N-740-2 (paragraph 1.2(e)(1)) is not applicable.

The NRC staff notes that contrary to the licensee's statement above, the delta ferrite number requirement in Code Case N-504-4 is applicable to the sulfur mitigation layer even though the mitigation layer is not considered for structural purpose. The purpose of the delta ferrite number requirement is to minimize cracking in the weld metal. Cracking in the sulfur mitigation layer would not be conducive to achieve a sound structural integrity of the overlaid DMWs, even if that layer is not being considered as a structural layer. However, the NRC staff notes that the licensee will use the ER309L weld filler material which has a 9 FN, and that the deposited weld will have at least a FN of 7.5. Based on this review, the NRC staff finds that the licensee has satisfied the delta ferrite number requirements of Code Case N-504-4.

### 3.3.4 Examination

#### 3.3.4.1 Pre-Installation Examination

As stated above, the licensee will perform a bare metal visual examination and penetrant testing of the subject DMWs prior to FSWOL installation as part of preparation. However, the licensee stated that it will not perform ultrasonic examinations of the subject DMWs prior to installing FSWOL. The NRC staff notes that the licensee is not required to perform UT of the subject DMWs prior to FSWOL installation. If UT is not conducted prior to FSWOL installation, the licensee is required to assume a 75 percent through-wall flaw occurring in the DMWs when it performs crack growth calculations, as described in Code Case N-740-2. As discussed above, the licensee has assumed a 75 percent flaw in the DMWs in its crack growth calculation. Therefore, the NRC staff finds that the assumed flaw in the DMWs is acceptable. The NRC staff notes that Section 2 of Code Case N-740-2 requires that if a flaw is detected in the outer 25 percent of the original weld after the FSWOL installation, the licensee is required to analyze the flaw that is a combination of the detected flaw size and the 75 percent through-wall flaw (i.e., adding both flaw depth) in the crack growth calculation.

After the FSWOL is installed, the proposed alternative requires the licensee to perform acceptance examination, pre-service examination, and inservice examination. The proposed alternative also specifies the required examination volume and area for each of these examinations as discussed below.

#### 3.3.4.2 Acceptance Examination

The required acceptance examination volume is the weld overlay itself and is shown in Figures 2(b)(1), 2(b)(2), and 2(b)(3) in the supplement dated January 17, 2013. As stated in Section 3(a) of Code Case N-740-2, the weld overlay will satisfy the surface examination acceptance criteria for welds of the Construction Code or the ASME Code, Section III, NB-5300. The weld overlay will also satisfy the volumetric examination acceptance standards of the ASME Code, Section XI, IWB-3514.

The licensee indicated that it will not be able to examine a small region of the required weld overlay volume at the elbow intrados because of the proximity of the elbow interfering with the UT transducer and causing transducer lift-off and loss of contact with the FSWOL. The licensee stated that the angle beam circumferential scans and the downstream axial scans will be reduced. The licensee will be able to provide examination coverage for the weld overlay that is located directly on top of welds MU-394BM and MU-395BM. The examination volume that the licensee will not be able to cover is in the weld overlay at the elbow, not at the DMWs. The NRC staff finds that the inspection of the structural integrity of the overlaid DMWs will not be affected by this missing volume coverage because the missing volume is not located directly on top of the DMWs.

#### 3.3.4.3 Preservice and Inservice Examinations

ASME Code Case N-740-2 provides requirements for the preservice and inservice examinations, including acceptance criteria, examination volume and inspection frequencies. The overlaid DMWs need to satisfy the acceptance standards of the ASME Code, Section XI,

IWB-3514 for the volumetric examination performed during the preservice and ISIs. In addition to ASME Code Case N-740-2, Section 5.0 of the relief request stated that preservice and inservice examination of the completed FSWOL will be performed according to ASME Code Case N-770-1, which is conditioned by 10 CFR 50.55a(g)(6)(ii)(F). By letter dated January 17, 2013, the licensee provided specific provisions in Code Case N-770-1 that are applicable to the examination of the overlaid DMWs. They are as follows:

- Section 2200, *Baseline Examination*, of Code Case N-770-1 which requires a baseline examination. The licensee stated that the DMWs have not received a baseline examination and a baseline examination cannot be adequately completed due to the current configuration. The current configuration does not allow for completing any axial scanning of the elbow to safe-end weld.
- Section 2220, *Preservice Examination After Repair/Replacement Activities or Stress Improvement*, of Code Case N-770-1 which requires a preservice examination of the finished FSWOL. The licensee stated that Table 1, Figure 2 of Code Case N-770-1 applies to the examination extent for preservice examination and the acceptance criteria of Section 3130 are applicable with limitations as noted in Section 2220.
- Section 2410, *Examination Program*, of Code Case N-770-1 which specifies provisions for the inservice examinations of the finished FSWOL. The licensee stated that Inspection Item F in Table 1 of Code Case N-770-1 applies, which identifies Figure 2 as the applicable examination extent and Section 3130 for acceptance criteria. The FSWOL will be re-examined during one of the next two refueling outages following application as required by Table 1 of Code Case N-770-1. If no indications of crack growth or new indications are identified in the examination performed no later than the second refueling outage after the FSWOL is installed, then the FSWOL will be included in a 25 percent sample of overlay repairs requiring examination during the inspection interval. Footnotes 1, 4, 6(a) (for Inspection Item F), 8, 9 and 10 of Table 1 are applicable to these examinations. The licensee stated that deferral of examinations as described in Footnote 11 will not be applied to this FSWOL application.
- Sections 2420, *Successive Examinations*, and 2500, *Examination Requirements*, of Code Case N-770-1 which are all applicable except -2500(b) because Section 2500(b) is related to cast stainless steel. The subject letdown nozzle does not contain cast stainless steel. The licensee stated that the additional requirements of 10 CFR 50.55a(g)(6)(ii)(F)(4) are applicable to Section 2500(c) which is related to examination coverage and which is discussed later in this safety evaluation in detail.
- The acceptance standards in Section 3130, *Inservice Volumetric Examinations*, of Code Case N-770-1 is applicable to this FSWOL including applicable 10 CFR 50.55a(g)(6)(ii)(F)(6) conditions.
- The acceptance standards in Section 3140, *Inservice Bare Metal Visual Examinations*, of Code Case N-770-1 are applicable because the licensee will perform a visual examination prior to FSWOL application, except that visual examinations after FSWOL application are not required by Code Case N-770-1. The NRC staff notes that the

licensee must follow the bare metal visual examination requirement mandated in 10 CFR 50.55a(g)(6)(ii)(E).

- Section 3200, *Supplemental Examinations*, of Code Case N-770-1 is applicable to the letdown nozzle FSWOL. Evidence of leakage prior to FSWOL application would be verified by performing a surface examination prior to welding the FSWOL. The licensee stated that a pre-FSWOL UT examination would not produce meaningful examination results because of weld configuration. The FSWOL is being applied to increase inspectability of the letdown nozzle DMWs. The licensee further stated that the post FSWOL UT examination will identify degradation within the outer 25 percent of the original pipe wall.

As a result of the FSWOL, the licensee classified the overlaid letdown nozzle as Inspection Item F per Table 1 of Code Case N-770-1. Item F is specified for cracked butt weld reinforced by FSWOL. The NRC staff has determined that Item F is an appropriate and acceptable classification because the licensee did not perform an UT examination prior to FSWOL installation and conservatively assumed the DMWs are degraded. The NRC staff finds that the licensee has identified sections in Code Case N-770-1 that are applicable to the FSWOL. The NRC staff notes that Code Case N-740-2 in the licensee's submittal dated January 17, 2013, also provides additional examination requirements for the FSWOL and the licensee needs to follow the examination requirements of Code Cases N-740-2 and N-770-1.

The NRC staff further finds that the proposed acceptance, pre-service, and inservice examinations are consistent with Appendix Q of the ASME Code, Section XI, and therefore acceptable.

#### 3.3.4.4 Examination Coverage

Section 5.0 of the relief request states that after the FSWOL is installed, UT examination coverage may achieve less than 98 percent of the required volume because of the intrados of the elbow, but it is still expected to be greater than 90 percent. By letter dated January 17, 2013, the licensee explained that the FSWOL will be examined in two axial directions and two circumferential directions for a total of four directions. The downstream scan will direct the UT beam toward the elbow and the upstream scan will direct the beam toward the nozzle. There will also be clockwise and counter clockwise circumferential scans. The NRC staff noted that the licensee will be able to achieve 100 percent coverage in the axial and circumferential scans of weld MU-394BM. The licensee can also achieve 100 percent coverage in the circumferential scan in all profile locations (0, 90, 180, and 360 degree) for weld MU-395BM without any limitations. However, the licensee is not able to achieve 100 percent coverage on the axial scan of weld MU-395BM.

The reduced coverage for weld MU-395BM in the axial scan is caused by the edge of the transducer wedge contacting the elbow intrados, causing transducer lift-off and loss of contact with the FSWOL surface. The limitation is maximum at the intrados. The licensee noted that the 100 percent coverage of susceptible material (i.e., the DMW) is achieved after the transducer travels +/-45 degree circumferentially from the intrados. Code Cases N-740-2 and N-770-1 require that at a minimum 100 percent of the overlaid DMW volume be covered by UT, if the coverage of the required examination volume cannot achieve 100 percent. The NRC staff

asked the licensee to justify how the structural integrity of weld MU-395BM can be verified in the future if 100 percent of examination coverage of the overlaid weld MU-395BM cannot be achieved. By letter dated January 17, 2013, the licensee responded that structural integrity of the overlaid weld MU-395BM is acceptable because:

1. There is excessive FSWOL thickness at the intrados. The minimum deposited FSWOL thickness is 0.30 inches. However, due to the elbow geometry at the intrados the FSWOL thickness is significantly greater at the intrados to allow for UT examination. A flaw that originates at the elbow DMW toe is expected to be detected as it grows through the Alloy 52M FSWOL material.
2. The licensee has performed a supplemental analysis to address potential flaws in the DMW in the region of limited coverage. Both axial and 360 degree circumferential flaws that extend through the full thickness of the original DMW material at the region of limited coverage are evaluated. The supplemental analysis results show that the final flaw depths after 22 years of service (through current end of license) is less than the allowable flaw depths per ASME Section XI acceptance criteria. Thus, the analysis demonstrates that the design has sufficient FSWOL thickness.
3. If a flaw initiates from the inside surface at the elbow to DMW interface, it is expected to follow the weld edge bevel towards the outside surface, which results in a flaw oriented so that detection is possible with the axial scan that is directed toward the elbow. The licensee stated that it is able to achieve 100 percent coverage of the susceptible material with the axial scan directed toward the elbow.
4. Degradation in the FSWOL material would be expected to be due to fatigue. Flaws due to fatigue in the FSWOL would be expected to be perpendicular to the outside surface of the FSWOL. This type of flaw would be detectable by the axial scan oriented toward the elbow.
5. Liquid penetrant examinations are performed prior to FSWOL application to verify the absence of surface flaws.

The NRC staff finds that the licensee will achieve sufficient examination coverage in the axial and circumferential scans to monitor the structural integrity of MU-395BM albeit a limited volume cannot be examined in the axial scan. The NRC staff notes that the overlay thickness at the elbow intrados region is thicker than the overlay on the DMWs because of the geometry. The thicker weld overlay will provide additional structural integrity for the elbow. Therefore, the NRC staff has reasonable assurance that overlaid weld MU395BM will maintain its structural integrity

#### 3.3.4.5 Performance Demonstration Initiative Program

The staff notes that the licensee previously submitted a separate proposed alternative request, I4R-05, "Request for Relief from Qualification Requirements of ASME Section XI, Appendix VIII, Supplement 11, for Examination of Structural Weld Overlays (SWOLs) in Accordance with 10 CFR 50.55a(a)(3)(i)." Request I4R-05 proposed alternatives to the ASME Code, Section XI, Appendix VIII, Supplement 11, inspection requirements which are applicable to the DM welds in RR-12-02 for the TMI-1 fourth 10-year ISI interval. The licensee

did not request any deviations from the NRC-approved proposed alternative request I4R-05 in RR-12-02. By letter dated July 20, 2011, the NRC authorized I4R-05 for use of the PDI program in lieu of the ASME Code, Section XI, Appendix VIII, Supplement 11, inspection requirements at TMI-1. The scope of I4R-05 includes NRC-approved FSWOL's applied during the fourth ISI interval at TMI-1, and therefore applies to the RR-12-02 overlay. Therefore, the NRC staff finds that the licensee is permitted to use the PDI program as described in alternative I4R-05 to examine FWSOL of the cold leg letdown nozzle DMWs.

### 3.3.5 Commitments

The licensee provided the following commitment in the application dated October 18, 2012:

Exelon Generation Company, LLC commits to providing the results of the ultrasonic examination of the Full Structural Weld Overlay on the TMI, Unit 1 lower cold leg letdown nozzle dissimilar metal welds and Alloy 600 safe-end. The results will include: (1) A list of the indications detected, (2) The disposition of all the indications using the standards of ASME Code Cases N-740-2 and N-770-1, (3) The type and, if possible, nature of the indications. Also included in the results will be a discussion of any repairs to the overlay material.

The licensee will provide the results within 30 days after the completion of the last UT examination of weld overlays during the fall 2013 TMI-1, T1R20 refueling outage. The NRC staff reviewed this commitment and finds it acceptable. The NRC staff also concludes that tracking this commitment under the licensee's commitment tracking program is appropriate.

## 4.0 CONCLUSION

In summary, the NRC staff finds that the requirements of proposed alternative RR-12-02 are consistent with the provisions of ASME Code Cases N-504-3, N-638-4, and N-770-1, Appendix Q of the ASME Code, Section XI, and MRP-169, Revision 1. Therefore, proposed alternative in RR-12-02 will provide reasonable assurance of structural integrity and leak tightness of the cold leg letdown nozzle, safe-end and the associated DMWs, after the FSWOL is installed. Accordingly, the staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(i).

On the basis of the review and evaluation of the licensee's submittals described above, the NRC staff concludes that the proposed alternative would provide an acceptable level of quality and safety. The staff also notes that the inspection requirements as mandated in 10 CFR 50.55a(g)(6)(ii)(F) are applicable to the future ISI of the overlaid DMWs and safe-end. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the use of RR-12-02 for the repair of the subject the cold leg letdown nozzle, safe-end, and associated Alloy 82/182 DM welds. The design and installation portion of RR-12-02 is authorized for the remaining life of the components, including future plant life extension. The inspection requirements of RR-12-02 are authorized for the TMI-1 fourth 10-year ISI interval, which will conclude on April 19, 2022.



All other ASME Code, Section XI, requirements for which relief was not specifically requested and authorized by the NRC staff remain applicable, including the third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributors: J. Tsao  
P. Bamford

Date: June 10, 2013

M. Pacilio

- 2 -

If you have any questions, please contact the TMI-1 Project Manager, Mr. Peter J. Bamford, at 301-415-2833.

Sincerely,

*/RA/*

Veronica Rodriguez, Acting Chief  
Plant Licensing Branch I-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-289

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