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10 CFR 50.55a

5928-07-20102
May 1, 2007

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Three Mile Island, Unit 1
Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Relief Request No. 2007-TMI-01 - Structural Weld Overlays (SWOLs) of the Pressurizer Surge, Pressurizer Spray, and Hot Leg Decay Heat Drop Line Nozzle Dissimilar Metal Welds including the SWOL of Adjacent Welds

Pursuant to 10 CFR 50.55a(a)(3)(i), AmerGen Energy Company, LLC (AmerGen) is proposing an alternative to the repair/replacement requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME), Section XI, 1995 Edition, through 1996 Addenda, for the structural weld overlays on the pressurizer surge, pressurizer spray, and hot leg decay heat drop line nozzle dissimilar metal welds. This relief will also include the structural weld overlay of the identified adjacent welds.

During the upcoming Three Mile Island (TMI), Unit 1 refueling outage (Fall 2007), AmerGen is planning to perform full structural weld overlays on the subject welds with the exception of the pressurizer spray nozzle welds, which will be ultrasonically examined during the upcoming outage. The pressurizer spray nozzle welds have been included in this relief request in the event that a repair is necessary during the upcoming outage in order to address examination findings.

We request your approval of the attached relief request by October 1, 2007 for use during the upcoming TMI, Unit 1 refueling outage (Fall 2007).

Additionally, AmerGen is committing to provide the details of the ultrasonic examination results of the structural weld overlays within 30 days of the completion of the final ultrasonic examinations. AmerGen will notify the NRC Project Manager for TMI, Unit 1 when the examinations of the final structural weld overlays are complete.

There is one (1) commitment contained in this letter as discussed in Attachment 1.

If you have any questions, please contact Mr. Thomas R. Loomis (610-765-5510).

Respectfully,

Russell G. West
Vice President – TMI, Unit 1

Attachments 1) Summary of Commitments
2) Relief Request No. 2007-TMI-01

cc: S. J. Collins, Regional Administrator, Region I, USNRC
D. M. Kern, USNRC Senior Resident Inspector, TMI
P. Bamford, Project Manager, USNRC
File No. 05056

ATTACHMENT 1

Summary of Commitments

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	Programmatic (Yes/No)
AmerGen commits to providing the results of the ultrasonic examination of the structural weld overlays on the TMI, Unit 1 welds PR-021BM, DH-001BM, DH-498, PR-009BM (if overlayed), and SP-021BM (if overlayed). The results will include: • A list of the indications detected[1], • The disposition of all the indications using the standards of ASME Section XI, Nonmandatory Appendix Q, • The type and, if possible, nature of the indications[2]. Also included in the results will be a discussion of any repairs to the overlay material.	Within 30 days after the completion of the last ultrasonic examination of the weld overlays during the Fall 2007 TMI, Unit 1 outage.	Yes	No

[1] The recording criteria of the ultrasonic examination procedure to be used for the examination of the TMI, Unit 1 pressurizer overlays (PDI-UT-8) requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration, be considered flaw indications.

[2] Ultrasonic examination procedure PDI-UT-8 requires that all suspected flaw indications are to be plotted on a sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.

ATTACHMENT 2

Relief Request No. 2007-TMI-01

Request for Relief for Alternative Requirements of Structural Weld Overlays (SWOLs) of the Pressurizer Surge, Pressurizer Spray, and Hot Leg Decay Heat Drop Line Nozzle Dissimilar Metal Welds including the SWOL of adjacent welds in accordance with 10 CFR 50.55a(a)(3)(i)

1.0 ASME CODE COMPONENT(S) AFFECTED

Code Class:	1
Reference:	IWA-4000, *"Repair/Replacement Activities"*
Examination Category:	R-A
Item Number:	See Table 1A for listing
Description:	SWOLs of the Pressurizer Surge, Pressurizer Spray, and Hot Leg Decay Heat Drop Line Nozzle Dissimilar Metal Welds including the SWOL of adjacent welds
Component Number(s):	See Table 1A for listing
Drawing Number(s):	1D-ISI-DH-001 1D-ISI-RC-005 1D-ISI-RC-012

2.0 APPLICABLE CODE EDITION AND ADDENDA

1. American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 1995 Edition through 1996 Addenda.
2. Pressurizer Code of Construction, ASME Code Section III 1965 Edition, through Summer 1967 Addenda
3. USAS B31.7, Nuclear Power Piping, February 1968 Draft Including June 1968 Errata
4. USAS B31.1, Power Piping, 1967 Edition

3.0 APPLICABLE CODE REQUIREMENT

1. American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 1995 Edition through 1996 Addenda, IWA-4000, "Repair/Replacement Activities".
2. Nuclear Regulatory Commission (NRC) conditionally approved Code Case N-504-2, *"Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1"* with condition as specified in Regulatory Guide (RG) 1.147 Revision 14.
3. NRC conditionally approved Code Case N-638-1, *"Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique Section XI, Division 1"* with condition as specified in Regulatory Guide (RG) 1.147 Revision 14.
4. ASME Code, Section XI, 1995 Edition including Addenda through 1996, Appendix VIII, Supplement 11, *"Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds".*

4.0 REASON FOR REQUEST

Dissimilar metal welds (DMWs) on US Pressurized Water Reactor (PWR) Reactor Coolant Systems (RCS) often consist of Alloy 82/182 weld material to connect stainless steel pipe and safe ends to vessel and piping nozzles, which are generally constructed using carbon or low alloy ferritic steel. These welds have shown a propensity for primary water stress corrosion cracking (PWSCC) degradation, especially in components subjected to higher operating temperatures, such as the pressurizer or hot leg.

Three Mile Island (TMI), Unit 1 plans to install full structural weld overlays (SWOL) on the pressurizer (PZR) surge nozzle to safe-end weld and the decay heat drop line nozzle to safe end weld (including the adjacent decay heat drop line similar metal weld) during the October, 2007 T1R17 Refueling Outage. TMI, Unit 1 is also including a contingent overlay repair of the pressurizer spray dissimilar metal welds should results from the planned October, 2007 ultrasonic examination identify a need for SWOL of the nozzle to safe end or safe end to pipe dissimilar metal welds.

AmerGen Energy Company, LLC, (AmerGen) is taking a proactive approach in addressing Alloy 600 PWSCC degradation by applying a preemptive SWOL to the surge and decay heat drop line nozzles. SWOLs have been used for several years on both boiling water reactors (BWR) and PWRs to arrest existing (or postulated) flaws from propagating while establishing a new structural pressure boundary. In some cases, SWOLs have been used to reestablish structural integrity of a dissimilar metal weld containing through wall leaking flaws. In addition to proactively

mitigating PWSCC in the dissimilar metal weld, the SWOL can provide an acceptable geometry that allows ultrasonic examination in accordance with Performance Demonstration Initiative (PDI), Materials Reliability Program (MRP), and ASME Section XI requirements.

The contingency overlay for the PZR spray nozzle dissimilar metal welds is included in this relief request because the two Alloy 82/182 welds associated with this nozzle are scheduled for examination during the October, 2007 refueling outage. Inclusion of the spray nozzle overlay repair contingency allows implementation of a pre-approved repair during the outage. This approach avoids taxing of NRC and AmerGen resources during the high workload outage season.

The welding will be utilizing a mechanized Gas Tungsten Arc Welding (GTAW) process and the ambient temperature temper bead method with ERNiCrFe-7A (Alloy 52*) weld metal. Manual GTAW, using Alloy 52, will only be permitted subsequent to the SWOLs being essentially completed. When temper bead welding is not required, manual GTAW may be used if local repairs of weld defects are necessary or if additional weld metal is required locally to form the final SWOL contour. Shielded metal arc welding (SMAW), using Alloy 152, would only be used to repair indications in the existing dissimilar metal welds prior to overlay initiation.

> * The material supplier's weld wire designation may be either 52M or 52MS. The "S" designates the process route that converts the hot-rolled billet into finished cold-drawn wire. The material properties are not affected. For this reason, references herein to 52M are considered to encompass 52MS filler material as well.

As discussed herein, there is no comprehensive criterion for a licensee to apply a SWOL repair to a dissimilar metal weld that is constructed of Alloy 82/182 weld material. The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 1995 Edition through 1996 Addenda, IWA-4000, is used for the TMI Station Section XI Repair/Replacement Program, but it does not contain the needed requirements for this type of weld overlay repair. Repair/replacement activities associated with weld overlays of this type are required to address materials, welding parameters, personnel radiation exposure concerns, operational constraints, examination techniques, and procedural requirements.

5.0 PROPOSED ALTERNATIVE AND BASIS FOR USE

Pursuant to 10 CFR 50.55a(a)(3)(i), AmerGen Energy Company, LLC proposes applying SWOLs designed in accordance with Code Case N-504-2 (Reference 1) including NRC conditions identified in Regulatory Guide 1.147 (Reference 2) with the modifications proposed in Table 2 of this relief request. In addition, Code Case N-638-1 (Reference 3) (including NRC conditions identified in Regulatory Guide 1.147 (Reference 2)) for temper bead welding will be used with modifications proposed in Table 3 of this relief request. Final UT examination of the finished SWOL will be

performed using Electric Power Research Institute (EPRI) PDI demonstrated ultrasonic examination procedures and personnel in lieu of the ASME Section XI, Appendix VIII, Supplement 11 (Reference 5) as proposed in Table 4 of this relief request.

Code Case N-504-2 is currently approved for use in RG 1.147 with additional conditions that ASME Code Section XI, 2005 Addenda, Appendix Q, be applied to use of the Code Case. The SWOL will extend around the full circumference of the applicable dissimilar metal weld as required by Code Case N-504-2. The specific thickness and length will be determined according to the guidance provided in Code Case N-504-2 and Regulatory Guide 1.147. The SWOL will completely cover the dissimilar metal weld and adjacent stainless steel material with Alloy 52M material to the extent that PWSCC susceptible material is mitigated and examination capability is maintained for adjacent welds. In the case of the decay heat drop line the SWOL covers the adjacent similar metal weld to provide the weld geometry required to perform the final volumetric examinations and obtain the required examination coverage volume.

Prior to installation of the SWOL, TMI Unit 1 will complete a bare metal visual examination of the PZR surge and decay heat drop line nozzles immediately after the insulation is removed in the area around the nozzle and dissimilar metal weld area to ensure that no through wall cracks exist prior to applying the overlay. The PZR spray nozzle dissimilar metal welds will receive bare metal visual and ultrasonic examinations and will only be overlay repaired if examination results indicate repair is necessary.

A liquid penetrant (PT) examination will be performed of the overlay area with an acceptance criteria that no indication greater than 1/16" is permitted. If any indication is found greater than 1/16", the indication will be removed or reduced below the acceptance criteria, and the PT performed again. If any indication(s) do require repair, the repair will be completed and the area will again have a PT completed for final acceptance.

The decay heat drop line adjacent stainless steel weld (DH-498) being overlayed during the October, 2007 refueling outage was not selected for examination during the Third ISI Interval. Weld DH-498 has not been selected for ASME Section XI examination since initial plant operation. Welds at hot leg or pressurizer temperature requiring ultrasonic examination per MRP-139 (Reference 6) are scheduled for ultrasonic examination or weld overlay during the October, 2007 refueling outage. Any expansion of examination scope due to unacceptable service induced flaws in weld DH-498 recorded during the associated SWOL examination will be based on an evaluation of the unacceptable flaw characteristics. This evaluation will include whether other Risk Informed Inservice Inspection (RISI)

elements in the segment are subject to the same root cause conditions. No additional examinations will be performed if there are no additional RISI elements identified as being susceptible to the same degradation mechanism. If the evaluation does identify a common degradation mechanism susceptibility, then additional examinations would be performed on those elements as required by the RISI program commitments.

Flaw evaluations in accordance with Code Case N-504-2(g)(2) and shrinkage stress effects analyses in accordance with Code Case N-504-2(g)(3) will be addressed through the approved overlay designs that are currently in development. These documents will be completed and approved for use prior to application at TMI, Unit 1.

Subsequent inservice examinations will be scheduled and performed in accordance with the requirements of Nonmandatory Appendix Q or alternate schedules accepted by the NRC.

Also included as part of this request (Enclosure 1) is a discussion addressing recent industry experience concerning hot cracking of the 52M nickel alloy weld overlay on austenitic stainless steel base materials with higher levels of sulfur.

6.0 DURATION OF THE PROPOSED ALTERNATIVE

The duration of the proposed alternative associated with the SWOL is the remaining service life of the components including future plant life extension. Relief from the Appendix VIII inspection requirements is requested through the end of the Third Ten Year ISI interval. The current ISI inspection interval is scheduled to end on April 19, 2011.

7.0 PRECEDENTS

Similar relief requests for SWOLs of dissimilar metal weld (both PWR and BWR) have been approved for a number of units throughout the industry (see References 7 through 10). A number of units have submitted relief requests citing similar proposed relief request methodology. These relief requests were associated with welding over detected or postulated flaws outside the acceptance criteria of Section XI utilizing proposed modifications to existing Code Cases N-504-2 and N-638-1 and NRC conditions for use.

8.0 REFERENCES

1. ASME Code Case N-504-2, *"Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping,"* dated March 12, 1997.

2. Regulatory Guide 1.147, *"Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1,"* Revision 14, August 2005.

3. ASME Code Case N-638-1, *"Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique,"* dated February 13, 2003.

4. American Society of Mechanical Engineers (ASME) Section XI Nonmandatory Appendix Q, Nonmandatory Appendix Q Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments, 2005 Addenda.

5. ASME Code, Section XI, 1995 Edition including Addenda through 1996, Appendix VIII, Supplement 11, *"Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds"*.

6. MRP-139, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guidelines (MRP-139)", EPRI Report Number 1010087, Final Report, August 2005.

7. Letter from Richard Laufer, NRC to Christopher M. Crane, AmerGen, *"Three Mile Island Nuclear Station, Unit 1 (TMI-1) Request for Relief From Flaw Removal, Heat Treatment, and Nondestructive Examination Requirements for the Third 10- year Inservice Inspection (ISI) Interval (TAC No. MC1201),"* dated July 21, 2004, ADAMS Accession Number ML041670510.

8. Letter from Richard J. Laufer, NRC, to Bryce L. Shriver, PPL Susquehanna, *"Susquehanna Steam Electric Station, Unit 1 – Relief from American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (ASME Code), Section XI Appendix VIII, Supplement 11, Requirements and Cases N-504-2 and N-638 Requirements (TAC Nos. MC2450, MC2451, and MC2594),"* dated June 22, 2005, ADAMS Accession Number ML051220568.

9. Richard J. Laufer, NRC, to Michael R. Kansler, Entergy Nuclear Operations, Inc., *"Pilgrim Nuclear Power Station Relief Request No. PRR-9 (TAC No. ML8292),"* dated March 22, 2006, ADAMS Accession Number ML060240055.

10. Michael L. Marshall Jr. (NRR) letter to Christopher M. Crane, Exelon Generation Company, LLC, *"Byron Station, Unit No. 1 – Evaluation of Relief Request I3R-08 Pertaining to Structural Weld Overlays (TAC No. MD1761),"* dated January 29, 2007, ADAMS Accession ML062510169.

11. William H. Bateman (NRR) letter to Michael Bratton, PDI Chairman, Entergy Nuclear Southwest, *"Weld Overlay Performance Demonstration Administered By PDI as an Alternative for Generic Letter 88-01 Recommendations,"* dated January 15, 2002, ADAMS Accession ML020160532.

12. *Repair and Replacement Applications Center: "Temperbead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding,"* EPRI, Palo Alto, CA: 2006. 1013558.

TABLE 1A COMPONENT IDENTIFICATION						
For TMI Unit 1 Pressurizer and Decay Heat Drop Line SWOL						
NOZZLE	**NOZZLE-TO-SAFE END WELD #**	**ITEM #**	**SIZE**	**ADJACENT WELD #**	**CONFIGURATION**	**ITEM #**
Welds Scheduled for Weld Overlay Repair During TMI Outage T1R17						
Surge	PR-021BM	R1.15	10"	NA – Will not be overlay repaired.	NA	NA
Decay Heat	DH-001BM	R1.15	12"	DH-498	Safe End to Pipe	R1.20
Welds Scheduled for Examination During TMI Outage T1R17 (Overlay Repair Applicable if Examination Results are Unacceptable)						
Spray	PR-009BM	R1.14 R1.15	4"	SP-021BM	Safe End to Elbow	R1.11 R1.15

Note: Item numbers reflect Risk-Informed classification per RISI Program.
R1.11: Elements Subject to Thermal Fatigue.
R1.14: Elements Subject to Crevice Corrosion Cracking.
R1.15: Elements Subject to Primary Water Stress Corrosion Cracking (PWSCC).
R1.20: Elements not Subject to a Damage Mechanism.

TABLE 1B COMPONENT MATERIAL			
Weld Number	**Component**	**Component**	**Component**
PR-021BM	Nozzle – P1	Weld –F43	Safe End – P8
DH-001BM	Nozzle – P1	Weld – F43	Safe End – P8
DH-498	Safe End – P8	Weld – A8	Pipe – P8
PR-009BM	Nozzle – P1	Weld – F43	Safe End – P43
SP-021BM	Safe End – P43	Weld – F43	Elbow – P8

TABLE 2 **DESIGN/MATERIAL/NONDESTRUCTIVE EXAMINATION** **Modifications to Code Case N-504-2 and ASME Section XI, Appendix Q**	
CODE CASE N-504-2 AND ASME SECTION XI APPENDIX Q	**PROPOSED MODIFICATIONS**
N-504-2: "*Reply:* It is the opinion of the Committee that, in lieu of the requirements of IWA-4120 in Editions and Addenda up to and including the 1989 Edition with the 1990 Addenda, in IWA-4170(b) in the 1989 Edition with the 1991 Addenda up to and including the 1995 Edition, and in IWA-4410 in the 1995 Edition with the 1995 Addenda and later Editions and Addenda, defect in austenitic stainless steel piping may be reduced to a flaw of acceptable size in accordance with IWB-3640, from the 1983 Edition with the Winter 1985 Addenda, or later Editions and Addenda, by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe, provided the following requirements are met:"	Modification: Code Case N-504-2 and Appendix Q will be used for the weld overlay of the P1, P8, F43 and/or P43 materials as defined in Table 1B. *Basis:* Code Case N-504-2 is accepted for use in the current NRC Regulatory Guide 1.147 Rev. 14, and has been used extensively in BWR primary system piping. More recently, N-504-2 (with modifications approved under relief request submittals) has been applied to PWR applications for the weld overlay repair of dissimilar metal welds with known flaws or to apply SWOLs as a PWSCC mitigation technique. Industry operating experience in the area has shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, ferritic base metal, or Alloy 52M weld metal. The 360° full structural weld overlay will control growth in a PWSCC crack and maintain RCS integrity. The applied SWOL will also induce compressive stress in the existing welds (dissimilar metal weld or similar metal weld), thus potentially impeding growth of reasonably shallow cracks. Furthermore, the SWOL will be sized to meet structural requirements without crediting integrity of the existing welds.

TABLE 2 **DESIGN/MATERIAL/NONDESTRUCTIVE EXAMINATION** **Modifications to Code Case N-504-2 and ASME Section XI, Appendix Q**	
CODE CASE N-504-2 AND ASME SECTION XI APPENDIX Q	**PROPOSED MODIFICATIONS**
N-504-2: "(b) Reinforcement weld metal shall be low carbon (0.035% maximum) austenitic stainless steel applied 360 deg. around the circumference of the pipe, and shall be deposited in accordance with a qualified welding procedure specification identified in the Repair Program." **Note: This requirement is similar to Appendix Q, Q-2000(a).**	Modification: Weld overlay filler metal shall be an austenitic nickel alloy (28% Cr min.) applied 360 deg. around the circumference of the item, and shall be deposited using a Welding Procedure Specification for groove welding, qualified in accordance with the Repair/Replacement Code and Owner's requirements and identified in the Repair/Replacement Plan. Basis: Industry operational experience has shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, ferritic base metal, or Alloy 52M weld metal.
N-504-2: "(e) The weld reinforcement shall consist of a minimum of two weld layers having as-deposited delta ferrite content of at least 7.5 FN. The first layer of weld metal with delta ferrite content of at least 7.5 FN shall constitute the first layer of the weld reinforcement design thickness. Alternatively, first layers of at least 5 FN may be acceptable based on evaluation." **Note: This requirement is similar to Q-2000(d) except that Q-2000(d) alternately allows the deposited first layers weld metal have a carbon content of <0.02% and an FN value of at least 5FN.**	Modification: Delta ferrite measurements will not be performed for weld overlay repairs using Alloy 52M weld metal. Basis: The deposited Alloy 52/52M is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% nickel). The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited from a filler material with a Cr content of at least 28%. When welding over an austenitic base material or austenitic filler material weld and the associated dilution zone from an adjacent ferritic base material, a diluted first layer of at least 24% Cr is acceptable, provided the Cr content of the deposited weld metal is determined by chemical analysis of a representative coupon. Alternatively, the first weld layer may be considered "sacrificial", and will not be credited towards the reinforcement design thickness.

TABLE 2 **DESIGN/MATERIAL/NONDESTRUCTIVE EXAMINATION** **Modifications to Code Case N-504-2 and ASME Section XI, Appendix Q**	
CODE CASE N-504-2 AND ASME SECTION XI APPENDIX Q	**PROPOSED MODIFICATIONS**
N-504-2: "(h) The completed repair shall be pressure tested in accordance with IWA-5000. If the flaw penetrated the original pressure boundary prior to welding, or if any evidence of the flaw penetrating the pressure boundary is observed during the welding operation, a system hydrostatic test shall be performed in accordance with IWA-5000. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed in accordance with IWA-5000." **Nonmandatory Appendix Q** (mandated through Regulatory Guide 1.147 Revision 14 as a condition of using Code Case N-504-2) states, "Ultrasonic examination personnel shall be certified in accordance with the Owner's written practice. Procedures and personnel shall be qualified in accordance with Appendix VIII."	Modification: A system leakage test at system nominal operating pressure in accordance with IWA-5000 as modified by Code Case N-416-3 shall be performed in accordance with the TMI Unit 1 ISI Program. Prior to the system leakage test, ultrasonic examination (UT) of the finished SWOL using EPRI PDI demonstrated weld overlay examination procedures and qualified examiners shall be performed. Basis: The TMI Unit 1 Third Interval ISI Program utilizes the 1995 Edition with Addenda through 1996 of ASME Code Section XI along with Code Case N-416-3 (approved for use through Regulatory Guide 1.147 Rev. 14) for NDE and pressure testing of welded repairs and replacements. Code Case N-416-3 permits a system leakage test in lieu of a hydrostatic test provided NDE is performed in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of ASME Code Section III. The 1992 Edition of ASME Code Section III Subsection NB does not address the structural weld overlay configuration, so the NDE requirements of Nonmandatory Appendix Q performed using EPRI PDI demonstrated procedures with qualified examiners will be used. The use of the EPRI PDI demonstration and qualification program in lieu of Appendix VIII is evaluated in Table 4 of this relief request.

TABLE 3
AMBIENT TEMPERATURE TEMPER BEAD WELDING
Modifications to Code Case N-638-1

CODE CASE N-638-1	PROPOSED MODIFICATIONS
1.0 General Requirements "(a) The maximum area of an individual weld based on the finished surface shall be 100 sq. in., and the depth of the weld shall not be greater than one-half of the ferritic base metal thickness."	Modification: The maximum area of an individual weld based on the finished surface over the ferritic material shall not exceed 300 sq. in. If any of the TMI, Unit 1 SWOL repairs exceed 300 sq. in. over the ferritic material, additional relief will be requested. The one half base metal thickness limitation applies only to excavation and repair and is not applicable to this repair. Basis: Although the final design for the TMI Unit 1 SWOL was not completed at the time of development of this relief request, it is anticipated that the SWOL will require welding on more than 100 sq. in. of surface on the carbon steel base material. The SWOL will extend to the transition taper of the carbon steel nozzle to provide a weld geometry that allows qualified UT examination of the required examination volume. There have been a number of temper bead SWOL repairs successfully applied to safe-end to nozzle welds in the nuclear industry, and a SWOL repair having a 300 sq. in. surface was approved for the Susquehanna Steam Electric Station (Reference 8).
4.0 Examination "(b) The final weld surface and the band around the area defined in para. 1.0(d) shall be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with Appendix I.[3]" "[3]Refer to the 1989 Edition with the 1989	Modification: For the SWOLs, full UT of the 1.5T band will not be performed. UT will be performed on the actual weld overlay, meeting the requirements of ASME Code Section XI, Nonmandatory Appendix Q-4100. When austenitic filler materials are used, the final SWOL will be examined using the surface and ultrasonic methods after three tempering weld layers (i.e., layers 1, 2, and 3) are completed and have been in place for at least 48 hours.

TABLE 3
AMBIENT TEMPERATURE TEMPER BEAD WELDING
Modifications to Code Case N-638-1

CODE CASE N-638-1	PROPOSED MODIFICATIONS
Addenda and later Editions and Addenda."	Basis: Later editions of the code as well as later revisions to the Code Case (N-638-2 and later) removed the requirement for the 1.5T examination band. This is in line with the less restrictive requirements for UT of the ferritic nozzle because hydrogen cracking away from the temper bead weld is not considered a concern in later editions of the code and Code Case N-638. The code case applies to any type of welding where a temper bead technique is to be employed (which includes weld repairs of excavated flaws) and is not specifically written for a SWOL repair. However, it is believed that for this type of repair, any major base material cracking would take place in the ferritic heat-affected zone directly below or adjacent to the weld overlay and not in the required 1.5T examination band of ferritic material beyond the overlay. If this type of cracking were to occur it should be detected by the NDE of the SWOL and adjacent ferritic steel surfaces. As supported by EPRI's white paper (Reference 12) providing the technical basis for Code Case N-638-4, the 48 hour hold time prior to final NDE examinations will start upon completion of the third temper bead weld overlay layer. Reference 12 addresses previous concerns regarding the 48-hour hold time prior to final NDE examinations. Areas of concern imposing the 48-hour hold time addressed through this report include: material microstructure; sources for hydrogen introduction; tensile stress and temperature; and diffusivity and solubility of hydrogen in steels. The report concludes there is no technical basis for waiting 48 hours after the weld overlay cools to ambient temperature before performing final NDE of the completed weld overlay. Based on past and recent NDE experience on

TABLE 3 **AMBIENT TEMPERATURE TEMPER BEAD WELDING** **Modifications to Code Case N-638-1**	
CODE CASE N-638-1	**PROPOSED MODIFICATIONS**
	temper bead weld overlays, hydrogen cracking of these welds was not identified during the initial NDE after a 48-hour hold time or subsequent inservice inspection examinations. Appendix I does not specifically address weld overlay ultrasonic examinations. Ultrasonic examinations shall be performed using EPRI PDI weld overlay demonstrated examination procedures with PDI qualified inspectors.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
1.0 SPECIMEN REQUIREMENTS	
1.1: "(b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 inches or larger, the specimen set must include at least one specimen 24 inches or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within –0.1 inches to +0.25 inches of the maximum nominal overlay thickness for which the procedure is applicable."	The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 inches or larger, the specimen set must include at least one specimen 24 inches or larger but need not include the maximum diameter. The specimen set shall include specimens with overlays not thicker than 0.1 inches more than the minimum thickness, nor thinner than 0.25 inches of the maximum nominal overlay thickness for which the procedure is applicable.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
1.1 (d) Flaw Conditions	
1.1(d): "*(1) Base metal flaws.* All flaws must be cracks in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75 percent through the base metal wall. Flaws may extend 100 percent through the base metal and into the overlay material; in this case, intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC [intergranular stress corrosion cracking] shall be used when available."	Base metal flaws: All flaws must be cracks in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75 percent through the base metal wall. Intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Specimens containing IGSCC shall be used when available. At least 70 percent of the flaws in the detection and sizing tests shall be cracks and the remainder shall be alternative flaws. Alternative flaws, if used, shall provide crack-like reflective characteristics and shall be limited by the following: (a) The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws. (b) Flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches.
1.1(e) Detection Specimens	
1.1(e): "(1) At least 20% but less than 40% of the flaws shall be oriented within +/- 20 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws."	At least 20% but less than 40% of the base metal flaws shall be oriented within +/- 20 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access.
1.1(e): "(2) Specimens shall be divided into base and over-lay grading units. Each specimen shall contain one or both types of grading units."	Specimens shall be divided into base metal and overlay fabrication grading units. Each specimen shall contain one or both types of grading units. Flaws shall not interfere with ultrasonic detection or characterization of other flaws.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
1.1(e) Detection Specimens	
1.1(e)(2)(a): "(1) A base grading unit shall include at least 3 inches of the length of the overlaid weld. The base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75% of the overlaid weld and base metal overlay material, or base metal-to-overlay interface."	A base metal grading unit includes the overlay material and outer 25 percent of the original overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 inch and shall start at the centerline and be wide enough in the axial direction to encompass one half of the original weld crown and a minimum of 0.50 inch of the adjacent base material.
1.1(e)(2)(a): "(2) When base metal cracking penetrates into the overlay material, the base grading unit shall include the overlay metal within 1 inch of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit."	When base metal flaws penetrate into the overlay material, the base metal grading unit shall not be used as part of any overlay fabrication grading unit.
1.1(e)(2)(a): "(3) When a base grading unit is designed to be unflawed, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen."	Sufficient unflawed overlaid weld and base material shall exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws.
1.1(e)(2)(b): "(1) An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 sq in. The overlay grading unit shall be rectangular, with minimum dimensions of 2 in."	An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 inch.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
1.1(e) Detection Specimens	
1.1(e)(2)(b): "(2) An overlay grading unit designed to be unflawed shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch around its entire perimeter. The specific area used in one overlay grading unit shall not be used in another overlay grading unit. Overlay grading units need not be spaced uniformly about the specimen."	Overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends. Sufficient unflawed overlaid weld and base metal shall exist on both sides of the overlay fabrication grading unit to prelude interfering reflections from adjacent flaws. The specific area used in one overlay fabrication grading unit shall not be used in another overlay fabrication grading unit. Overlay fabrication grading units need not be spaced uniformly about the specimen.
1.1(e)(2)(b): "(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base grading units, ten unflawed base grading units, five flawed overlay grading units, and ten unflawed grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units."	Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base metal grading units, ten unflawed base metal grading units, five flawed overlay fabrication grading units, and ten unflawed overlay fabrication grading units. For each type of grading unit, the set shall contain at least twice as many unflawed grading units. For initial procedure qualification, detection sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.
1.1(f) Sizing Specimen	
1.1(f): "(1) The minimum number of flaws shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface."	The minimum number of flaws shall be ten. At least 30 percent of the flaws shall be overlay fabrication flaws. At least 40 percent of the flaws shall be open to the inside surface. Sizing sets shall contain a distribution of flaw dimensions to assess sizing capabilities. For initial procedure qualification, sizing sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
1.1(f) Sizing Specimen	
1.1(f): "(3) Base metal cracking used for length sizing demonstrations shall be oriented circumferentially."	Base metal flaws used for length sizing demonstrations shall be oriented circumferentially.
1.1(f): "(4) Depth sizing specimen sets shall include at least two distinct locations where cracking in the base metal extends into the overlay material by at least 0.1 in. in the through-wall direction."	Depth sizing specimen sets shall include at least two distinct locations where a base metal flaw extends into the overlay material by at least 0.1 inch in the through-wall direction.
2.0 CONDUCT OF PERFORMANCE DEMONSTRATION	
"The specimen inside surface and identification shall be concealed form the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate review of unmasked specimens after the performance demonstration is prohibited."	The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. The overlay fabrication flaw test and the base metal flaw test may be performed separately.
2.1 Detection Test	
"Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base or overlay) that are present for each specimen."	Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base metal or overlay fabrication) that are present for each specimen.
2.2 Length Sizing Test	
2.2(d) "For flaws in base grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base wall thickness."	For flaws in base metal grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25 percent of the base metal wall thickness.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
2.3 Depth Sizing Test	
"For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region."	(a) The depth sizing test may be conducted separately or in conjunction with the detection test. (b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of Supplement 11, 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region. (c) For each separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.
3.0 ACCEPTANCE CRITERIA	
3.1 Detection Acceptance Criteria	
"Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units."	Examination procedures are qualified for detection when; a) All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls. b) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (c). c) Examination equipment and personnel are qualified for detection of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. d) The criteria in (b) and (c) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.

TABLE 4 **MODIFICATIONS TO APPENDIX VIII, SUPPLEMENT 11**	
Appendix VIII, Supplement 11	**PDI Modification**
3.2 Sizing Acceptance Criteria	
3.2: "(a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. The length of base metal cracking is measured at the 75% through-base-metal position."	The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal 0.75 inch. The length of base metal flaws is measured at the 75 percent through-base-metal position.
3.2: "(b) All extensions of base metal cracking into the overlay material by at least 0.1 inch are reported as being intrusions into the overlay material."	This requirement is omitted.

ENCLOSURE 1

Barrier Layer to Prevent Hot Cracking in High Sulfur Stainless Steel

Background

During recent dissimilar metal weld (DMW) overlay activities, where use of ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) has been used for the filler metal, flaws in the first layer have occurred in the portion of the overlay deposited on the austenitic stainless steel portions (safe ends, pipe etc.) of the assemblies in some cases.

The applicable stainless steel materials at TMI, Unit 1 where the full structural weld overlay (SWOL) will be deposited are as follows:

- Pressurizer surge nozzle safe end is A 336 Class F8M.
- Hot leg pipe decay heat drop line nozzle safe end is A 336 Class F8M and attached pipe is A 376 TP316 and pipe-to-safe end weld is Type 316 stainless steel.
- Pressurizer spray line elbow attached to pressurizer spray nozzle safe end is A403 WP316.

Discussion

The characteristics of the flaws described above are indicative of hot cracking. This phenomenon has not been observed on the ferritic steel or ENiCrFe-3 (Alloy 182) DMWs.

Further studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Limited tests and evaluations recently performed by AREVA have resulted in the conclusion that welding with Alloy 52M on stainless steel base material with 0.020 wt% sulfur results in cracking while welding on stainless steel base materials with less than 0.010 wt% have resulted in no cracking.

To reduce the susceptibility of hot cracking occurrence due to welding Alloy 52M on the stainless steel base materials with high sulfur, AREVA has selected ER309L filler metal as the preferred filler metal to provide a barrier layer between the Alloy 52M and the high sulfur stainless steel base material. This filler metal is compatible with the base material and promotes primary weld metal solidification as ferrite rather than austenite. The ferrite is more accommodating of residual elements therein and in the underlying base material thereby significantly reducing the susceptibility to hot cracking. ER309L is also compatible with the Alloy 52M. However, the barrier layer will necessarily consist of ERNiCr-3 (Alloy 82) being used locally at the interface between the Alloy 182 DMW and the stainless steel item. ER309L welding on Alloy 182 may result in cracking of the ER309L weld. Welding on high sulfur stainless steel with Alloy 82 has not been a concern relevant to hot cracking occurrence.

AREVA welded a mockup to evaluate the interactive effects, such as hot cracking and lack of fusion, between the Alloy 182 DMW, the stainless steel base material, the ER309L and Alloy 82 barrier layer, and the subsequent Alloy 52M weld overlay. The mockup assembly consisted of a stainless steel pipe (0.020 wt% sulfur) with an Alloy 182 groove weld. The barrier layer and overlay were welded in the same sequence as performed in the field (barrier layer ER309L and Alloy 82 and then two layers of Alloy 52M overlay). The barrier layer and overlay welding parameters used in the mockup were similar to those used in the field however slightly reduced wire feed rates were used for conservatism.

The following examinations were performed on the final mockup and no recordable indications were detected:

PT examination was performed on the:

- High sulfur stainless steel base material
- Alloy 182 Groove Weld
- ER309L Barrier Layer
- Alloy 82 Barrier Layer
- Alloy 52M Overlay

Limited PDI UT examination

- 0° Transducer with Full Coverage
- 45° Transducer with Full Coverage
- OD Creeper Transducer with Full Coverage
- 60° Transducer with limited coverage (Focal depth exceeded UT procedure allowable in places due to overlay being of insufficient thickness. Only two layers of Alloy 52M were deposited.)

Initial metallographic examination searching for any type of discontinuity, flaw or other anomaly (single specimen with "rough" polish and etch) has been performed on the first specimen.

Metallography will also be performed on seven additional specimens (total of eight specimens removed in approximate 45° circumferential increments around the pipe) searching for any discontinuities, flaws or other anomalies. Preliminary evaluations of all the specimens have shown no conditions causing concern at this stage.

Conclusion

More tests and evaluations would be necessary to accurately determine the threshold where the base metal sulfur content would require barrier layer welding.

Based on the information herein TMI, Unit 1 will use a barrier layer prior to overlay on all stainless steel components with sulfur content greater than 0.010 wt% and may opt to use a barrier layer on all stainless steel components. Based on review of certified material test report sulfur contents, the austenitic stainless steel items shown below will require a barrier layer:

- Hot leg pipe decay heat drop line nozzle safe end is A 336 Class F8M and attached pipe is A 376 TP 316 and pipe-to-safe end weld is Type 316 stainless steel.
- Pressurizer spray elbow attached to pressurizer spray nozzle safe end is A403 WP316.

The barrier layer will use ER309L on the stainless steel and Alloy 82 on the stainless steel near the DMW to stainless steel fusion zone only.

Structural credit will not be assumed for the barrier layer in determining the required minimum overlay thickness.

The barrier layer welding will be performed in accordance with ASME Code Section IX qualified welding procedure specification(s). PT examination will be performed on the barrier layer surface and its volume will be included in the final UT of the overlay.