Mr. H. B. Barron
Group Vice President,
Nuclear Generation
and Chief Nuclear Officer
P.O. Box 1006-EC07H
Charlotte, NC 28201-1006

SUBJECT: CATAWBA NUCLEAR STATION, UNIT 2, AND MCGUIRE NUCLEAR STATION, UNIT 1, RELIEF 07-GO-001 FOR USE OF PREEMPTIVE WELD OVERLAY AND ALTERNATIVE EXAMINATION TECHNIQUES ON SAFE END WELDS (TAC NOS. MD4671 AND MD4672)

Dear Mr. Barron:

By letter dated January 24, 2007, Duke Power Company, LLC (Duke or the licensee) submitted Relief Request (RR) No. 07-GO-001, pertaining to the preemptive weld overlays and inspection of the weld overlays at Catawba Nuclear Station (CNS), Unit 2, and McGuire Nuclear Station (MNS), Unit 1. The licensee requested approval of proposed alternatives to the American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code* (Code), 1998 edition through the 2000 addenda. The licensee proposed the use of full structural preemptive weld overlays and temper bead welding for repair of various pressurizer nozzle-to-safe end welds. In addition, the licensee proposed alternatives for the examination of the repairs by using the performance demonstration initiative program for the ultrasonic examination of the full structural weld overlay repair, and the examination of the dissimilar metal welds.

The Nuclear Regulatory Commission (NRC) staff has reviewed and evaluated the licensee's submittal and based on the information provided, concludes that the proposed alternatives provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternatives are authorized for the repair and examination of the various pressurizer nozzle-to-safe end welds at CNS Unit 2 and MNS Unit 1.

Verbal relief was authorized by the NRC staff for CNS Unit 2 and MNS Unit 1 during a teleconference with the licensee on April 26, 2007.

The enclosed Safety Evaluation contains the NRC staff's evaluation and conclusions.

Sincerely,

Evangelos C. Marinos, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-414 and 50-369

Enclosure:
Safety Evaluation

cc w/encl: See next page

The enclosed Safety Evaluation contains the NRC staff's evaluation and conclusions.

Sincerely,

Evangelos C. Marinos, Chief
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Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST TO USE PREEMPTIVE WELD OVERLAY AND ALTERNATIVE

EXAMINATION TECHNIQUES ON SAFE END WELDS

DUKE POWER COMPANY, LLC

CATAWBA NUCLEAR STATION, UNIT 2, AND

MCGUIRE NUCLEAR STATION, UNIT 1

DOCKET NOS. 50-414 AND 50-369

1.0 INTRODUCTION

By letter to the Nuclear Regulatory Commission (NRC), dated January 24, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML070310367), Duke Energy Company, LLC (Duke, the licensee), proposed alternative 07-GO-001, for Catawba Nuclear Station, Unit 2 (CNS Unit 2), and McGuire Nuclear Station, Unit 1(MNS Unit 1), to the repair requirements of American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code), Section XI.

The licensee proposed to use Code Cases N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1;" N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten-Arc Welding] Temper Bead Technique;" and Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds;" with modifications in lieu of the requirements of the 1998 edition through the 2000 addenda of ASME Code, Section XI. The NRC staff has completed its review of Request for Alternative 07-GO-001 for CNS Unit 2 and MNS Unit 1 which are addressed in the following safety evaluation (SE). The alternatives would be used to perform preemptive full structural weld overlays on pressurizer spray, relief, safety, and surge nozzle safe ends.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 55a(g)(4) (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

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inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) twelve months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI Code of Record for CNS Unit 2 and MNS Unit 1 for the third 10-year ISI interval is the 1998 edition of the ASME Code through the 2000 addenda. The third 10-year interval for CNS Unit 2 and MNS Unit 1 ends on August 19, 2016, and December 1, 2011, respectively.

Pursuant to 10 CFR 50.55a(a)(3)(i), alternatives to requirements may be authorized by the NRC if the licensee demonstrates that the proposed alternatives provide an acceptable level of quality and safety .

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee submitted Request for Alternative 07-GO-001, which proposed alternatives to the implementation of the ASME Code, Section XI, IWA-4000 and Appendix VIII, Supplement 11. The licensee's alternative is based on Code Cases N-504-2 and N–638-1, with modifications, for the deposition of preemptive full structural weld overlays and the performance demonstration initiative (PDI) program implementation of Appendix VIII.

3.0 PROPOSED ALTERNATIVE 07-GO-001

3.1 Code Requirements

The 1998 edition, through the 2000 addenda, of ASME Code, Section XI, Article IWA-4000, "Repair/Replacement Activities," and Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds."

3.2 System/Component(s) for which Relief is Requested

The components for which the relief request applies are pressurizer nozzle to safe end dissimilar metal welds and stainless steel safe end to reactor coolant system (RCS) piping welds. The components are Code Class 1. The examination category for the subject welds at MNS Unit 1 is risk-informed (R-A) and the examination category for subject welds at CNS Unit 2 is B-F and B-J. The Code item number for MNS Unit 1 is R01.011 and for CNS Unit 2 are B5.40 and B9.11. The welds that are included in this relief request are listed in below.

McGuire Unit 1	Description	Size	Weld Number	Comment[(1)]
Pressurizer	Surge nozzle to safe end	15" OD	1PZR-W1SE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Spray nozzle to safe end	6" OD	1PZR-W2SE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Relief nozzle to safe end	8" OD	1PZR-W3SE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8" OD	1PZR-W4ASE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8" OD	1PZR-W4BSE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8" OD	1PZR-W4CSE	LAS nozzle/Alloy 82-182 weld/SS safe end
RC Pipe	Surge safe end to pipe	14" Sch 160	NC1F3612	SS safe end/SS weld/SS pipe
RC Pipe	Spray safe end to Pipe	4" Sch 160	NC1F1746	SS safe end/SS weld/SS pipe
RC Pipe	Relief safe end to Pipe	6" Sch 160	NC1F546	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6" Sch 160	NC1F542	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6" Sch 160	NC1F544	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6" Sch 160	NC1F1850	SS safe end/SS weld/SS pipe

Catawba Unit 2	Description	Size	Weld Number	Comment[(1)]
Pressurizer	Surge nozzle to safe end	15” OD	2PZR-W1SE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Spray nozzle to safe end	6 OD	2PZR-W2SE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Relief nozzle to safe end	8” OD	2PZR-W4CSE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8” OD	2PZR-W4ASE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8” OD	2PZR-W4BSE	LAS nozzle/Alloy 82-182 weld/SS safe end
Pressurizer	Safety nozzle to safe end	8” OD	2PZR-W3SE	LAS nozzle/Alloy 82-182 weld/SS safe end
RC Pipe	Surge safe end to pipe	14” Sch 160	2NC8-3	SS safe end/SS weld/SS pipe
RC Pipe	Spray safe end to Pipe	4” Sch 160	2NC44-28	SS safe end/SS weld/SS pipe
RC Pipe	Relief safe end to Pipe	6” Sch 160	2NC177-7	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6” Sch 160	2NC119-1	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6” Sch 160	2NC163-1	SS safe end/SS weld/SS pipe
RC Pipe	Safety safe end to Pipe	6” Sch 160	2NC112-5	SS safe end/SS weld/SS pipe

(1) LAS = SA-508 Class 2 Grade 2 low alloy steel.
SS safe end = Type 316 austenitic stainless steel.
SS pipe = Type 304 austenitic stainless steel.

3.3 Licensee’s Reason For Requesting Alternative

Dissimilar metal welds (DMW) made with nickel alloys 82 and 182 have been shown to be susceptible to primary water stress corrosion cracking (PWSCC) degradation in components associated with the pressurizer that are subjected to higher operating temperatures. Structural weld overlays have been used for several years on piping of both boiling water reactors and pressurized water reactors to arrest the growth of existing flaws while establishing a new structural pressure boundary. No evidence of PWSCC has been found in the welds of the MNS Unit 1 or CNS Unit 2 pressurizer nozzles. However, PWSCC is difficult to detect in DMW except when the inspection is performed in accordance with the stringent requirements of ASME Code, Section XI, Appendix VIII. The DMW included in this request for relief have been evaluated and found not to meet the surface or geometric requirements of nondestructive examination of Appendix VIII. The feasibility of modifying the geometry to an acceptable configuration has not been established. Duke is proposing to take a proactive approach to apply a preemptive full structural weld overlay (PWOL) to the dissimilar metal welds of the pressurizer components listed above.

Currently, there are no comprehensive criteria for a licensee to apply a full structural weld overlay to DMW constructed of Alloy 82/182 weld material. Neither the latest NRC-approved edition nor the edition of ASME Code, Section XI used for the MNS Unit 1and CNS Unit 2 repair/replacement program, contains the needed requirements for this type of repair. Repair/replacement activities associated with a full structural weld overlay repair of this type are required to address the materials, welding parameters, as low as reasonably achievable concerns, operational constraints, examination techniques, and procedure requirements. Similar nozzle-to-safe end weld overlays have been applied to other plants since 1986 with no problems identified.

3.4 Licensee's Proposed Alternative and Bases

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposes an alternative to the ASME Code requirements listed in Section 3.1 above on the basis that its proposed alternative will provide an acceptable level of quality and safety. Specific details of the licensee's request are listed in Tables A1, A2, and A3, of Request for Alternative 07-GO-001.

3.4.1 Code Case N-504-2

The licensee proposed the following alternatives to Code Case N-504-2:

Code Case N-504-2 will be used for weld overlay repairs to the ferritic (P3), nickel alloy (F43/P43), and the austenitic stainless steel (P8) base material. Code Case N-504-2 is accepted for use along with Nonmandatory Appendix Q in the current NRC Regulatory Guide (RG) 1.147, Rev. 14. For the weld overlay of the identified welds at MNS Unit 1 and CNS Unit 2, the base material will be ferritic material (P3) with existing nickel alloy weld metal (F43/P43) to which an austenitic stainless steel (P8) safe end is welded. 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 52/52M/52MS weld metal. The 360 degrees structural weld overlay will control growth in any PWSCC crack and maintain weld integrity. The weld overlay will induce compressive stress in the lower portion of the weld, thus impeding growth of any shallow cracks initiated from the inside diameter surface. Furthermore, the overlay will be sized to meet all structural requirements independent of the existing weld.

In lieu of austenitic stainless steel filler material, the reinforcement weld metal will be a nickel alloy. The weld metal used may be ERNiCrFe-7A (Alloy 52M, UNSN06054) or ERNiCrFe-7 (Alloy 52 UNS N06052). This weld metal is assigned F43 by ASME per Code Case 2142-2. The requirements of ASME Section III, NB-2400 will be applied to all filler material. The chromium content of Alloy 52M/52MS is 28-31.5%, identical to that of Alloy 52. The main difference in Alloy 52 vs. Alloy 52M/52MS is a higher Niobium content (0.5-1%). The higher Niobium content in Alloy 52M/52MS improves the weldability of the material by pinning the grain boundaries to prevent separation between the grains and hot tearing during weld puddle solidification. These filler materials were selected for their improved resistance to PWSCC. Alloys 52 and 52M/MS contain about 30% chromium that imparts excellent corrosion resistance. The existing Alloy 82/182 weld and the Alloy 52M/52MS overlay are nickel base and have ductile properties and toughness similar to austenitic stainless steel piping welds at pressurized water reactor operating temperature. These filler materials are suitable for welding over the ferritic nozzle, Alloy 82/182 weld, and the austenitic stainless steel safe end or pipe components.

Delta ferrite (FN) measurements will not be performed for weld overlay repairs made of Alloy 52/52M/52MS weld metal. Welds of Alloy52/52M/52MS are 100% austenitic and contain no delta ferrite due to the high nickel composition (approximately 60% nickel).

If a flaw or evidence of a flaw is observed, in lieu of hydrostatic testing, a system leakage test and an ultrasonic examination (UT) of the weld overlay will be performed consistent with ASME IWA-4540(a)(2), as modified by Nonmandatory Appendix Q. Application of IWA-4540(a)(2) for a system leakage test in lieu of a system hydrostatic test requires performance of non-destructive examination (NDE) in accordance with the methods and acceptance criteria of the applicable Subsection of the1992 edition of ASME Code, Section III. ASME Code, Section III, Subsection

NB, Article 5000 for examination does not address the structural weld overlay type configuration. The NDE requirements of Nonmandatory Appendix Q will be followed for the required NDE in lieu of ASME Code, Section III. Code Case N-504-2 and Nonmandatory Appendix Q provide appropriate examination requirements including examination volume, acceptance criteria, and examination methods per Appendix VIII.

3.4.2 Code Case N-638-1

The licensee proposed the following alternatives to Code Case N-638-1:

The maximum area of an individual weld based on the finished surface over the ferritic material will not exceed 500 square inches. The depth of the weld is not applicable to the weld overlay (WOL) configuration and is not addressed in this request. The maximum area of the WOL for the surge line nozzle will be approximately 120 square inches over the ferritic material. An ASME Code white paper providing technical justification for extending the area limitation to 500 square inches was published by the ASME Code Committees. As previously noted in the text, this white paper has been submitted to the NRC for its use.

Of the required examinations of 4.0(b) of the Code case, only the required liquid penetrant examination will be performed. In lieu of the required ultrasonic examination, the ultrasonic examination will be in accordance with N-504-2 and Appendix Q. For the application of the weld overlay repair addressed in this request, the appropriate examination methodologies and volumes are provided in Code Case N-504-2 and Nonmandatory Appendix Q. Code Case N-638-1 applies to any type of welding where a temper bead technique is to be employed and is not specifically written for a weld overlay repair. As described in the text of this request, the proposed inspection will provide equal or better assurance of the soundness of repaired volume, the weld overlay and surrounding material.

Preheat and interpass temperatures for the weld overlay will be measured using a temporarily attached or contact pyrometer. Readout of the temperature may be local using a manual method or remotely monitored by the operator. Interpass temperature control required by Code Case N-638-1 will be maintained. The proposed technique is faster and does not compromise collection of required data. The proposed technique provides data equivalent to that obtained from weld attached thermocouples to monitor interpass temperature during welding.

3.4.3 Appendix VIII, Supplement 11

The licensee proposed the following alternatives:

Appendix VIII of Section XI cannot be used for NDE of a structural weld overlay repair. Relief is requested to use the PDI program implementation of Appendix VIII. A detailed comparison of Appendix VIII and Performance Demonstration Initiative (PDI) requirements is summarized [in Table A2 of the submittal]. Relief is requested to allow closer spacing of flaws provided the flaws do not interfere with detection or discrimination of other discontinuities. The specimens used for qualification to the Tri-party (NRC/BWROG/EPRI) agreement have a flaw population density greater than allowed by current Code requirements. These samples have been used successfully for all previous qualifications under the Tri-party agreement program. To facilitate their use and provide continuity from the Tri-party agreement program to Supplement 11, the PDI program has merged the Tri-party test specimens into their structural weld overlay program.

4.0 NRC STAFF'S EVALUATION

The licensee's relief request to apply full structural PWOL and inspection is intended as a proactive approach to mitigate potential effects of PWSCC. The proposed alternative will be employed at CNS Unit 2 and MNS Unit 1 during each unit's current third 10-year ISI interval. The welds that the licensee intends to install on the PWOL are DMWs between low alloy steel (P3) material and stainless steel (P8) safe ends made with Alloy 82/182 weld filler metal. Alloy 82/182 filler metal is susceptible to PWSCC. Due to the close proximity of the stainless steel RCS piping (P8) to stainless steel (P8) safe end welds, these similar metal welds will be installed with the PWOL also. The welds included in the licensee's request are on piping and nozzles with an outside diameter up to 15 inches.

In the relief request, the licensee proposed to use modified versions of ASME Code Cases N-504-2 and N-638-1, to install the full structural weld overlays. The PWOL is proposed as an alternative to the Code requirements in IWA-4000. For the inspection of the weld overlay, the licensee proposed the use of the PDI program as an alternative to the ASME Code requirements of Section XI of Appendix VIII, Supplement 11. The NRC staff has approved both code cases with conditions as shown in RG 1.147, Revision 14. Both code cases provide acceptable alternatives to the Code requirements. The NRC staff's evaluation of the proposed alternatives relating to the relief/modifications to ASME Code, Section XI of IWA-4000, Code Case N-504-2, Code Case N-638-1 and Appendix VIII, Supplement 11, are provided below.

4.1 Modifications to Code Case N-504-2

Code Case N-504-2 allows the use of weld overlay repair by deposition of weld reinforcement on the outside surface of the pipe in lieu of mechanically reducing a defect to an acceptable flaw size. However, the subject code case is written for repairing austenitic stainless steel piping. Therefore, the material requirements of the carbon content limitation (0.035% maximum) and the delta ferrite content of at least 7.5 FN as delineated in Code Case N-504-2 paragraphs (b) and (e), respectively, apply only to austenitic stainless steel weld filler metals. The carbon content limitation of 0.035% is to ensure resistance to intergranular stress-corrosion cracking, and a minimum ferrite content of at least 7.5 FN is to prevent weld solidification cracking and to provide enough retained ferrite in the weld to increase resistence to stress corrosion cracking. These requirements are not applicable to ERNiCrFe-7 (Alloy 52) or ERNiCrFe-7a (Alloy 52M/52MS) because they are nickel-based materials which the licensee will use for weld overlay repair. For material compatibility in welding, the NRC staff considers Alloy 52 and Alloy 52M/52MS to be a better choice of filler material than austenitic stainless steel material for this weld joint configuration. Use of a stainless steel filler material would result in a very low FN due to dilution of nickel from the existing Alloy 82/182 weld. As a result, the weld would be highly susceptible to weld solidification cracking. Alloys 52 and 52M/52MS are fully austenitic and do not rely on primary solidification as ferrite to resist cracking. The resulting weld would therefore not contain ferrite.

Weld metals ERNiCrFe-7 and ERNiCrFe-7a are listed in ASME Code, Section II, Part C and are assigned an F-number grouping of F-43 in ASME Code, Section IX. These weld filler metals are acceptable to use on ASME Code Class 1, 2 and 3 components. ERNiCrFe-7 and ERNiCrFe-7a contain 28 - 31.5% chromium which provides resistance to stress corrosion cracking (SCC) in the reactor coolant environment. ERNiCrFe-7a is identical to ERNiCrFe-7 in chemistry with the exception that ERNiCrFe-7a has a higher content of Niobium (0.5 - 1.0%) for

the purpose of improving its weldability. Both of these weld filler metals have been widely used in the nuclear industry to make weld repairs similar to the licensee's proposal. Therefore, the licensee's proposed use of ERNiCrFe-7 or ERNiCrFe-7a for the weld overlay repair as an alternative to the weld filler metal requirements of Code Case N-504-2 paragraphs (b) and (e) is acceptable as the proposed weld metal will provide an acceptable level of quality and safety.

Code Case N-504-2 requires that a completed repair be pressure tested in accordance with IWA-5000. If a flaw penetrates the original pressure boundary prior to welding or during welding, a hydrostatic test is to be performed. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed. The licensee's alternative specifies a system leakage test and a UT examination of the weld overlay consistent with IWA-4540(a)(2), as modified by Appendix Q. IWA-4540 (a)(2) requires nondestructive testing methodology and acceptance criteria of the 1992 edition or later of the ASME Code, Section III when a system leakage test is performed. The NRC staff's evaluation of the licensee's use of Appendix Q in lieu of ASME Code, Section III acceptance criteria is detailed below. The NRC staff considers that the licensee's alternative to use IWA-4540(a)(2) with Appendix Q acceptance criteria provides an acceptable level of quality and safety.

4.2 Modifications to Code Case N–638-1

When using Code Case N-638-1, the condition listed in RG 1.147 must be met. The condition requires that define UT volumetric examinations be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 in the 1998 edition through 2000 addenda of ASME Code, Section III apply to all flaws identified within the repaired volume. The licensee's alternative specifies the acceptance criteria listed in ASME Code, Section XI, Appendix Q. ASME Code, Section III flaw acceptance standards are derived from the capability of radiography to detect and size flaws originating from the fabrication process used during new facility construction. The ASME Section III acceptance criteria do not allow for the presence of any cracks or crack-like indications, regardless of their size, and are geared more towards volumetric flaws. The capability of radiography is a function of density differences such as 2% or greater changes in density. The density changes normally associated with cracks, depending on orientation, are much less than the detection capability of radiography. There is an inherent, unknown tolerance in the ASME Code, Section III acceptance criteria for radiography which encompasses tight cracks and densities below the detection capabilities of radiography. Flaws detected using radiography are not precise enough for applying Section XI crack growth analyses, as flaw depth cannot be measured with radiography.

ASME Code, Section III radiography is not applicable for evaluating flaws for continued plant operations because of the difficulty associated with depth sizing flaws.

The use of Code Case N-504-2, in the licensee's alternative, is for applying austenitic nickel based (Alloy 52\52M) weld metal on austenitic stainless steel base material. The use of Code Case N-638-1 is to apply austenitic weld metal on ferritic base material using a controlled heat input that relieves welding stresses and prevents crack-sensitive microstructures in the ferritic material. The purpose of Code Case N-638-1 is to establish an austenitic surface for the application of Code Case N-504-2 to complete the structural weld overlay.

Many flaws that are not detected or accurately sized with radiography have a high likelihood of being detected and sized with UT, depending on orientation. These flaws are normally detected with UT during the Section XI preservice inspection. Also, the preservice UT is used to characterize flaws detected during the Section III radiography examination. The flaws of concern are the ones that cause failure immediately or grow to failure in the future. The Section XI preservice acceptable flaw standards were developed to consider the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural impact of the flaw on the component. The flaws detected during preservice inspections are subjected to periodic inservice inspections as established in Appendix Q, Q-4300. This includes inspection frequencies for monitoring existing crack growth and identifying new cracks. Thus, the established preservice NDE acceptance criteria in Code Case N-504-2 for weld overlays made with Alloy 52/52M weld metal also apply to the portion of the weld overlay made during the application of N-638-1 as modified by this safety evaluation.

Section 1.0(a) of Code Case N-638-1 states, "The maximum area of an individual weld based on the finished surface shall be 100 square inches, and the depth of the weld shall not be greater than one half of the ferritic base metal thickness." The licensee seeks to increase the maximum allowable finished weld surface area above the current allowable 100 square inches to no greater than 500 square inches. The licensee indicated that the maximum area of the weld overlay on ferritic material is the surge line nozzle which will be approximately 120 square inches. The licensee also indicated that it believes that the weld depth restriction described above does not apply. Some of the reasons for these limits on area are distortion of weld and base metal, cracking in the weld and base metal, and high residual stresses when a large repair excavation is being performed in the ferritic material of a dissimilar metal weld. In the application of the PWOL for this relief request, there is no large excavation in the ferritic portion of the material. Therefore, the 100-square-inch limitation does not significantly contribute to cracking when the ferritic material is overlaid rather than excavated. An ASME Code white paper (ADAMS Accession No. ML070470565) was previously submitted to the NRC which describes a technical justification for allowing overlay areas up to 500 square inches. The white paper describes analytical and experimental programs that indicate that residual stress distributions for weld overlay repairs of 100 square inches up to 500 square inches are comparable. The NRC staff has approved requests for some licensees to perform weld overlays that cover over 100 square inches and, to date, operational experience has shown that these larger weld overlay areas provide reasonable assurance of structural integrity. Based on operational experience with structural weld overlays and the information provided by the licensee, the NRC staff concludes that the licensee's proposed alternative to perform full structural weld overlay on areas no greater than 500 square inches and apply a weld overlay thickness that exceeds half of the ferritic material thickness provides reasonable assurance of structural integrity of repaired welds.

Code Case N-638-1 requires that the completed weld receive a surface and ultrasonic examination of the weld and a band around the area of at least 1.5 times the component thickness (1.5T) or 5 inches whichever is less. The licensee will perform a surface examination of the area required by the code case. In lieu of the required ultrasonic examination in Code Case N-638-1, the licensee will perform the ultrasonic examination in accordance with Code Case N-504-2 and Appendix Q of ASME Code, Section XI.

The ultrasonic examination will not completely cover the required volume per code case N-638-1 of base materials 1.5T from the edge of the weld, although a significant portion of the required inspection volume will receive a PDI qualified UT examination.

Using Code Case N-638-1, the temper bead weld is for filling a cavity in the base metal. The licensee's application, however, is for structural weld overlay above the base metal, which results in a contour that is UT inspectible except for the edge taper where the overlay transitions to the nozzle surface and on the curvature of the nozzle. The proposed weld edge configuration has the same UT examination difficulties as are considered under ASME Code, Section XI, Appendix Q. Appendix Q only requires a surface examination of the tapered area of the weld overlay. In addition to verifying the soundness of the weld, a purpose of the ultrasonic examination is to assure that delayed cracking that may be caused by hydrogen introduced during the temper bead welding process or cracking in unannealed ferritic material is not present. In the unlikely event cracking does occur, it would be initiated on the surface on which the welding is actually performed or in the heat affected zone immediately adjacent to the weld. The most appropriate technique to detect surface cracking is the surface examination technique. Therefore, use of a surface examination in the area of the weld overlay taper and band beyond the toe of the overlay on the ferritic material is acceptable in that it provides an adequate level of quality and safety.

When using Code Case N-638-1, monitoring of preheat and interpass temperature is required to be performed using welded thermocouples per IWA-4610(a). The licensee intends to use temporarily attached contact pyrometers and manual recording. The pyrometers will be calibrated with a quality assurance program approved by the licensee. The NRC staff concludes that the licensee's use of contact pyrometers in lieu of thermocouples is acceptable because the contact pyrometers used in this repair will be properly calibrated and will provide reasonable assurance that the temperature of the components during the welding process will be maintained within the required minimum preheat temperature and the maximum interpass temperature.

4.3 Modifications to Appendix VIII, Supplement 11

The U.S. nuclear utilities created the PDI to implement performance demonstration requirements contained in Appendix VIII of Section XI of the ASME Code. To this end, PDI has developed a program for qualifying equipment, procedures, and personnel for examinations of weld overlays in accordance with the UT criteria of Appendix VIII, Supplement 11. Prior to the Supplement 11 program, Electric Power Research Institute (EPRI) maintained a performance demonstration program for weld overlay qualification under the Tri-party Agreement[1]. Instead of having two programs with similar objectives, the NRC staff recognized the PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement[2]. Although the PDI program was developed for ISI at BWR plants, it is applicable to PWR plants like CNS Unit 2 and MNS Unit 1 because the application for PWOL use is the same concept.

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1 The Tri-party Agreement is between NRC, EPRI, and the Boiling Water Reactor Owners Group (BWROG), "Coordination Plan for NRC/EPRI/BWROG Training and Qualification Activities of NDE (Nondestructive Examination) Personnel," July 3, 1984.

2 US NRC Letter from William H. Bateman to Michael Bratton, "Weld Overlay Performance Demonstration Administered by PDI as an Alternative for Generic Letter 88-01 Recommendations," January 15, 2002. ML020160532

The PDI program does not fully comport with the existing requirements of Supplement 11. PDI presented the differences at public meetings in which the NRC participated[3, 4]. The differences are in flaw location within test specimens and fabricated flaw tolerances. The changes in flaw location permitted using test specimens from the Tri-party Agreement, and the changes in fabricated flaw tolerances provide UT acoustic responses similar to the responses associated with intergranular stress corrosion cracking.

There are differences between the PDI program and Supplement 11. The differences are identified in the following Supplement 11 paragraphs: 1.1(b), 1.1(d)(1), 1.1(e)(1), 1.1(e)(2), 1.1(e)(2)(a)(1), 1.1(e)(2)(a)(2), 1.1(e)(2)(a)(3), 1.1(e)(2)(b)(1), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), 2.3, 3.1, 3.2(a), 3.2(b) and 3.2(c), and are evaluated below:

Paragraph 1.1(b) of Supplement 11 states limitations to the maximum thickness for which a procedure may be qualified. Paragraph 1.1(b) states that, "The specimen set must include at least one specimen with overlay thickness within minus 0.10-inch to plus 0.25-inch of the maximum nominal overlay thickness for which the procedure is applicable." The Paragraph 1.1(b) requirement addresses the specimen thickness tolerance for a single specimen set, but is confusing when multiple specimen sets are used. The PDI proposed alternative states that "the specimen set shall include specimens with overlay not thicker than 0.10-inch more than the minimum thickness, nor thinner than 0.25 inch of the maximum nominal overlays thickness for which the examination procedure is applicable." The proposed alternative provides clarification on the application of the tolerance. The tolerance is unchanged for a single specimen set; however, the proposed alternative clarifies the tolerance for multiple specimen sets by providing tolerances for both the minimum and maximum thicknesses. The proposed wording eliminates confusion while maintaining the intent of the overlay thickness tolerance. Therefore, the NRC staff finds this PDI program alternative maintains the intent of the Supplement 11 requirements and is acceptable.

Paragraph 1.1(d)(1) requires that all base metal flaws be cracks. PDI determined that certain Supplement 11 requirements pertaining to location and size of cracks would be extremely difficult to achieve. For example, flaw implantation requires excavating a volume of base material to allow a pre-cracked coupon to be welded into this area. This process would add weld material to an area of the specimens that typically consists of only base material, and could potentially make ultrasonic examination more difficult and not representative of actual field conditions. In an effort to satisfy the requirements, PDI developed a process for fabricating flaws that exhibit crack-like reflective characteristics. Instead of all flaws being cracks, as required by Paragraph 1.1(d)(1), the PDI weld overlay performance demonstrations contain at least 70% cracks with the remainder being fabricated flaws exhibiting crack-like reflective characteristics. The fabricated flaws are semi-elliptical with tip widths of less than 0.002 inches. The licensee provided further information describing a revision to the PDI program alternative to clarify when real cracks, as opposed to fabricated flaws, will be used: "Flaws shall be limited to the cases where implantation of cracks produces spurious reflectors that are uncharacteristic of actual

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[3] US NRC Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held January 31 - February 2, 2002, with PDI Representatives," March 22, 2002. ML010940402

[4] US NRC Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held June 12 through June 14, 2001, with PDI Representatives," November 29, 2001. ML013330156

flaws." The NRC has reviewed the flaw fabrication process, compared the reflective characteristics between actual cracks and PDI-fabricated flaws, and found the fabricated flaws for this application provide assurance that the PDI program meets the intent of the Supplement 11 requirements. Therefore, the NRC staff finds the proposed alternative to the Supplement 11 requirements is acceptable.

Paragraph 1.1(e)(1) requires that at least 20% but less than 40% of the flaws shall be oriented within $\pm$20 degrees of the axial direction (of the piping test specimen). Flaws contained in the original base metal heat-affected zone satisfy this requirement; however, PDI excludes axial fabrication flaws in the weld overlay material. PDI has concluded that axial flaws in the overlay material are improbable because the overlay filler material is applied in the circumferential direction (parallel to the girth weld); therefore, fabrication anomalies would also be expected to have major dimensions in the circumferential direction. The NRC finds that this approach to implantation of fabrication flaws is reasonable for meeting the intent of the Supplement 11 requirements. Therefore, the NRC staff concludes that the PDI's exclusion of flaws oriented in the axial direction in the overlay material is acceptable.

Paragraph 1.1(e)(1) also requires that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. PDI treats each flaw as an individual flaw and not as part of a system of closely spaced flaws. PDI controls the flaws going into a test specimen set such that the flaws are free of interfering reflections from adjacent flaws. In some cases this permits flaws to be spaced closer than what is allowed for classification as a multiple set of flaws by IWA-3300, thus potentially making the performance demonstration more challenging than the existing requirements. Hence, the NRC staff concludes that PDI's control for closely spaced flaws is acceptable.

Paragraph 1.1(e)(2) requires that specimens be divided into base metal and overlay grading units. The PDI program adds clarification with the addition of the word "fabrication" and ensures flaw identification by ensuring all flaws will not be masked by other flaws with the addition of, "Flaws shall not interfere with ultrasonic detection or characterization of other flaws." PDI's alternative provides clarification and assurance that the flaws are identified.

Therefore, the NRC staff finds the PDI alternative to the Supplement 11 requirements is acceptable.

Paragraph 1.1(e)(2)(a)(1) requires that a base grading unit shall include at least three inches of the length of the overlaid weld, and the base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The PDI program reduced the criteria to one inch of the length of the overlaid weld and eliminated from the grading unit the need to include both sides of the weld. The proposed change permits the PDI program to continue using test specimens from the existing weld overlay program which have flaws on both sides of the welds. These test specimens have been used successfully for testing the proficiency of personnel for over 16 years. The weld overlay qualification is designed to be a near-side (relative to the weld) examination, and it is improbable that a candidate would detect a flaw on the opposite side of the weld due to the sound attenuation and re-direction caused by the weld microstructure. However, the presence of flaws on both sides of the original weld (outside the PDI grading unit) may actually provide a more challenging examination, as candidates must determine the relevancy of these flaws, if detected. The NRC staff concludes that PDI's use of the one-inch length of the overlaid weld base grading unit and elimination from the grading unit the need to

include both sides of the weld, as described in the PDI program alternative, is an acceptable alternative to the Supplement 11 requirements. Therefore, the NRC staff finds the proposed alternative acceptable.

Paragraph 1.1(e)(2)(a)(2) requires, when base metal cracking penetrates into the overlay material, that a portion of the base grading unit shall not be used as part of the overlay grading unit. The NRC staff finds that the PDI program adjusts for the changes in Paragraph 1.1(e)(2)(a)(2) and conservatively states that when base metal flaws penetrate into the overlay material, no portion of it shall be used as part of the overlay fabrication grading unit. The NRC staff finds that the PDI program also provided clarification by the addition of the term "flaws" for "cracks" and the addition of "fabrication" to "overlay grading unit." The NRC staff concludes that the PDI program alternative provides clarification and conservatism and, therefore, is acceptable.

Paragraph 1.1(e)(2)(a)(3) requires that for unflawed base grading units, at least one inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. This is to minimize the number of false identifications of extraneous reflectors. The PDI program stipulates that unflawed overlaid weld and base metal exists on all sides of the grading unit and flawed grading units must be free of interfering reflections from adjacent flaws which addresses the same concerns as the ASME Code. Hence, the NRC staff concludes that the PDI's application of the variable flaw-free area adjacent to the grading unit meets the intent of the Supplement 11 requirements and is, therefore, acceptable.

Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches. The PDI program reduces the base metal-to-overlay interface to at least one inch (in lieu of a minimum of two inches) and eliminates the minimum rectangular dimension. This criterion is necessary to allow use of existing examination specimens that were fabricated in order to meet NRC Generic Letter 88-01 (Tri-party Agreement, July 1984). This criterion may be more challenging to meet than that of the ASME Code because of the variability associated with the shape of the grading unit. Therefore, the NRC staff concludes that PDI's application of the grading unit is an acceptable alternative to the Supplement 11 requirements and is acceptable.

Paragraph 1.1(e)(2)(b)(2) requires that unflawed overlay grading units shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least one inch around its entire perimeter. The PDI program redefines the area by noting unflawed overlay fabrication grading units shall be separated by at least one inch of unflawed material at both ends and sufficient area on both sides to preclude interfering reflections from adjacent flaws. The NRC staff determined that the relaxation in the required area on the sides of the specimens, while still ensuring no interfering reflections, may provide a more challenging demonstration than required by ASME Code because of the possibility for having a parallel flaw on the opposite side of the weld. Therefore, the NRC staff concludes that the PDI's application is an acceptable alternative to the Supplement 11 requirements.

Paragraph 1.1(e)(2)(b)(3) requirements are retained in the PDI program. The PDI program allows procedure qualification to be performed separately from personnel and equipment qualification. Historical data indicate that, if ultrasonic detection or sizing procedures are thoroughly tested, personnel and equipment using those procedures have a higher probability of

successfully passing a qualification test. In an effort to increase this passing rate, PDI has elected to perform procedure qualifications separately. In addition, the PDI program requires that initial procedure qualification contain three times the number of flaws required for a personnel qualification. To qualify new values of essential variables, the equivalent of at least one personnel qualification set is required. The NRC staff concludes that PDI's additions enhance the ASME Code requirements and are, therefore, acceptable because it provides for a more stringent qualification criteria.

Paragraph 1.1(f)(1) requirements are retained in the PDI program, with the clarification change of the term "flaws" for "cracks." In addition, the PDI program includes the requirements that sizing sets shall contain a distribution of flaw dimensions to verify sizing capabilities. The PDI program also requires that initial procedure qualification contain three times the number of flaws required for a personal qualification. To qualify new values of essential variables, the equivalent of at least one personal qualification set is required. The NRC staff concludes that PDI's additions enhance the ASME Code requirements and are, therefore, acceptable because it provides a more stringent qualification criteria.

Paragraphs 1.1(f)(3) and 1.1(f)(4) requirements are clarified by the PDI program by replacing the term "cracking" with "flaws" because of the use of alternative flaw mechanisms. The NRC staff concludes that this clarification in the PDI program meets the intent of the ASME Code requirements and is acceptable.

Paragraph 2.0 requirements are retained in the PDI program alternative. In addition, the PDI program provides clarification that the overlay fabrication flaw test and the base metal flaw test may be performed separately. The NRC staff concludes that this clarification in the PDI program meets the intent of the ASME Code requirements and is acceptable.

Paragraphs 2.1 and 2.2(d) requirements are clarified by the PDI program by the addition of the terms "metal" and "fabrication". The NRC staff determined that the clarifications provide acceptable classification of the terms they are enhancing. Therefore, the NRC staff concludes that the PDI program meets the intent of the ASME Code requirements and is acceptable.

Paragraph 2.3 requires that, for depth sizing tests, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. This requires detection and sizing tests to be performed separately. The PDI revised the weld overlay program to allow sizing to be conducted either in conjunction with, or separately from, the flaw detection test. If performed in conjunction with detection and the detected flaws do not meet the Supplement 11 range criteria, additional specimens will be presented to the candidate with the regions containing flaws identified. Each candidate will be required to determine the maximum depth of flaw in each region. For separate sizing tests, the regions of interest will also be identified and the maximum depth and length of each flaw in the region will similarly be determined. In addition, PDI stated that grading units are not applicable to sizing tests, and that each sizing region will be large enough to contain the target flaw, but small enough such that candidates will not attempt to size a different flaw. The NRC staff determined that the above clarification provides a basis for implementing sizing tests in a systematic, consistent manner that meets the intent of Supplement 11. Therefore, the NRC staff concludes that the PDI's method is acceptable.

Paragraph 3.1 requires that examination procedures, equipment and personnel (as a complete ultrasonic system) are qualified for detection or sizing of flaws, as applicable, when certain criteria are met. For a procedure to be qualified, the PDI program requires all the flaws within the scope of the procedure be detected which is a more stringent criteria than the detection in Table VIII S2-1 of Appendix VIII to ASME Code, Section XI; therefore, the PDI program criteria exceed the ASME Code requirements for procedures and equipment qualification, and the personnel will meet the existing code requirements. Therefore, the NRC staff concludes that the PDI program criteria are acceptable.

Paragraph 3.2(a) requirements are clarified by the PDI program by replacing the term "cracking" with "flaws" because of the use of alternative flaw mechanisms. The NRC staff concludes that this clarification in the PDI program maintains the intent of the ASME Code requirement and is acceptable.

Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.10 inch are reported as being intrusions into the overlay material. The PDI program omits this criterion because of the difficulty in actually fabricating a flaw with a 0.10-inch minimum extension into the overlay, while still knowing the true state of the flaw dimensions.

However, the PDI program requires that cracks be depth-sized to the tolerance specified in the ASME Code which is 0.125 inches. Since the ASME Code tolerance is close to the 0.10-inch value of Paragraph 3.2(b), any crack extending beyond 0.10 inch into the overlay material would be identified as such from the characterized dimensions. The NRC staff determined that reporting of an extension in the overlay material is redundant for performance demonstration testing because of the flaw sizing tolerance. Therefore, the NRC staff concludes that PDI's omission of highlighting a crack extending beyond 0.10 inch into the overlay material is acceptable.

Paragraph 3.2(c) is renumbered to Paragraph 3.2(b) in the PDI program. The NRC staff concludes that this PDI program change is administrative in nature and is, therefore, acceptable. Based on the above evaluation, the NRC staff has determined that the licensee's proposed alternative to use the PDI qualification program for the ultrasonic examination of PWOLs is acceptable because it will provide an acceptable level of quality and safety.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that Request for Alternative 07-GO-001 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the use of Request for Alternative 07-GO-001 for the preemptive full structural weld overlay repair and inspection of the pressurizer DMWs for the remainder of the third 10-year ISI intervals at CNS Unit 2 and MNS Unit 1.

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

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