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

August 17, 2017

Mr. Daniel G. Stoddard
Senior Vice President and Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Blvd.
Glen Allen, VA 23060

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 - PROPOSED ALTERNATIVE TO IMPLEMENT CODE CASE N-839 (CAC NOS. MF8866 AND MF8867)

Dear Mr. Stoddard:

By letter dated November 22, 2016 (Agencywide Documents Access and Management System Accession No. ML16333A003), Virginia Electric and Power Company (the licensee) submitted requests N1-I4-CMP-002 and N2-I4-CMP-001 to the U.S. Nuclear Regulatory Commission (NRC) for the use of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code Case N-839, "Similar and Dissimilar Metal Welding using Ambient Temperature SMAW [shielded metal arc welding] Temper Bead Technique Section XI" at the North Anna Power Station, Units 1 and 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50.55a(z)(2), the licensee requested approval for the use of proposed alternatives N1-I4-CMP-002 and N2-I4-CMP-001 on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the proposed alternative provides reasonable assurance of structural integrity or leak tightness of the subject components, and that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Pursuant to 10 CFR 50.55a(z)(2), the NRC staff authorizes the use of the proposed alternatives N1-I4-CMP-002 and N2-I4-CMP-001 for the remainder of the fourth 10-year inservice inspection intervals at North Anna Power Station, Units 1 and 2, that are scheduled to end on April 30, 2019, and December 13, 2020, respectively.

All other ASME Code requirements for which alternatives or relief were not specifically requested and approved in the subject request remain applicable.

If you have any questions, please contact the NRC Project Manager, Randy Hall, at 301-415-4032 or via e-mail at Randy.Hall@nrc.gov.

Sincerely,

Shawn Williams for

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosure:
Safety Evaluation

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ALTERNATIVES TO UTILIZE CODE CASE N-839

FOURTH 10-YEAR INSERVICE INSPECTION INTERVALS

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-338 AND 50-339

1.0 INTRODUCTION

By letter dated November 22, 2016 (Agencywide Documents Access and Management System Accession No. ML16333A003), Virginia Electric and Power Company (the licensee), submitted requests N1-I4-CMP-002 and N2-I4-CMP-001 to the U.S. Nuclear Regulatory Commission (NRC) for the use of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code Case N-839, "Similar and Dissimilar Metal Welding using Ambient Temperature SMAW [shielded metal arc welding] Temper Bead Technique Section XI," at the North Anna Power Station (NAPS), Units 1 and 2.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(2), the licensee requested approval for the use of proposed alternatives N1-I4-CMP-002 and N2-I4-CMP-001 on the basis that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

2.0 REGULATORY EVALUATION

Adherence to Section XI of the ASME BPV Code is mandated by 10 CFR 50.55a(g)(4), which states, in part, that ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME BPV Code, Section XI.

The regulation in 10 CFR 50.55a(z) states, in part, that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be used, when authorized by the NRC, if the licensee demonstrates that: (1) the proposed alternative provides an acceptable level of quality and safety, or (2) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

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

3.0 TECHNICAL EVALUATION

3.1 Licensee's Request for Alternative

3.1.1 Component Identification

The affected components are ASME Code Class 1, 2, and 3 components fabricated from P-Nos. 1 and 3 materials, and their associated welds and welds joining P-No. 8 or P-No. 43 materials to P-Nos. 1 and 3 materials. The proposed alternative will not be used to repair SA-302, Grade B material, unless the material has been modified to include 0.04 percent to 1.0 percent nickel, quenched and tempered, and produced to fine grain practice.

3.1.2 Applicable Code Edition

The Code of Record for the fourth 10-year inservice inspection (ISI) intervals at NAPS, Units 1 and 2, is the ASME BPV Code, Section XI, 2004 Edition, No Addenda.

3.1.3 Applicable Code Requirement

The ASME BPV Code, Section XI, IWA-4400, provides requirements for welding, brazing, metal removal, fabrication, and installation of repair/replacement activities. IWA-4411 requires that weld preheat and postweld heat treatment (PWHT) be performed in accordance with the Code of Construction of the item.

3.1.4 Reason for Request

The licensee stated that applicable elevated preheat and PWHT required by the Construction Code necessitates draining the item to be repaired, installation of heating elements, establishing preheat, and completing PWHT. The licensee states that performing these activities requires additional manpower and the time required to perform these activities increases personnel radiation dose. In addition, draining the item to apply preheat and PWHT may not be practical.

The licensee stated that ASME BPV Code Case N-638-4 "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc welding] Temper Bead Welding, Section XI, Division 1," provides an NRC acceptable alternative to elevated preheat and PWHT. However, Code Case N-638-4 uses GTAW equipment and welding operator expertise that requires considerable pre-planning for deployment and effective implementation. The licensee states that these resources may not be readily available, particularly for emergent repair scenarios.

The licensee states that its proposed alternative provides a technically sound alternative to Construction Code requirements for elevated preheat and PWHT while eliminating the hardship resulting from adhering to Construction Code requirements.

3.1.5 Licensee's Proposed Alternative and Basis for Use

Pursuant to 10 CFR 50.55a(z)(2), the licensee proposed an alternative to the requirements of IWA-4000, for ASME Code Class 1, 2, and 3, related to preheat and PWHT required by the Construction Code for items requiring repair by welding. Specifically, the licensee proposes to use ASME Code Case N-839, with certain modifications. ASME Code Case N-839 provides requirements for the application of ambient temperature temper bead welding using the shielded metal arc welding (SMAW) process.

The licensee proposes to implement Code Case N-839 for repairs to P-Nos. 1 and 3 materials, and their associated welds and welds joining P-No. 8 or P-No. 43 materials to P-Nos. 1 and 3 materials. The licensee's proposed alternative restricts the applicability of Code Case N-839 Paragraph 1(a) so that old P-No. 12A, P-No. 12B, or P-No. 12C materials that have been subsequently reclassified to other than P-No. 1 or P-No. 3 (specifically P-Nos. 9A, 9B, or 10A) shall not be welded using its alternative. Footnote 1 on page 1 of Attachment 1 to the licensee's November 22, 2016, submittal provides a list of those materials that were previously identified as P-Nos. 12A, 12B, or 12C materials that are now classified as P-No. 1 or P-No. 3 materials and may be welded using the proposed alternative.

The licensee stated that Code Case N-839 uses the SMAW process at ambient temperature (50 degrees Fahrenheit (F) minimum). Welds made at ambient temperatures cool faster than welds made with elevated preheat. The faster cooling rate of ambient temperature temper bead welding provides greater assurance of formation of untempered martensite in the heat affected zone (HAZ) after cooling, which is then tempered by adjacent beads and subsequent weld layers to form tempered martensite that has superior fracture toughness. Welding using elevated preheat may not develop cooling rates fast enough to produce as much untempered martensite. The licensee states that for this reason, ambient temperature temper bead welding is expected to produce equivalent or superior HAZ fracture toughness compared to weldments utilizing elevated preheat (with or without PWHT being performed).

The licensee stated that Code Case N-839 invokes ASME BPV Code, Section IX, QW-290 rules for qualification of welding procedures and personnel. The licensee noted that Code Case N-762 "Temper Bead Procedure Qualification Requirements for Repair/Replacement Activities Without Postweld Heat Treatment," also invokes QW-290 for temper bead qualification. Code Case N-762 has been accepted by the NRC, without conditions, in Regulatory Guide (RG) 1.147, Revision 17, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1" (ADAMS Accession No. ML13339A689).

The licensee stated that Code Case N-839 does not require prior simulated PWHT of the procedure qualification test assembly as specified in Code Cases N-762 and N-638-4. Code Cases N-762 and N-638-4 require that test assemblies receive a simulated PWHT for at least the time and temperature that was applied to the materials being welded. The licensee states that excessively long simulated PWHT times degrade base material toughness properties, making it easier to demonstrate improvement in HAZ toughness from temper bead welding. Simulated PWHT is permitted in Code Case N-839, however, it is not permitted to exceed the time or temperature already applied to the base material to be welded.

Code Case N-839 provides alternative options to those listed in Code Case N-638-4 for selection of the procedure qualification Charpy V-notch (CVN) test temperature. The licensee believes that the alternative options are more appropriate for modern steelmaking practices where the base metal impact toughness is vastly superior to vintage materials.

The licensee stated that Code Case N-839 imposes limitations on welding electrodes to prevent hydrogen induced cracking (HIC). The licensee states that the code case requirement to use electrodes with moisture resistant coatings that have a low diffusible hydrogen limit produces welds with diffusible hydrogen levels similar to those made when implementing ambient temperature temper bead welding using the GTAW process (as in Code Case N-638-4).

The licensee believes that waiting 48 hours after completion of welding to perform surface and volumetric examinations, as required by the code case, provides defense in depth.

The licensee noted that ambient temperature temper bead welding using the GTAW process has been the predominant form of temper bead welding applied at U.S. nuclear facilities for over a decade and was most recently approved by the NRC through the use of Code Case N-638-4 in RG 1.147, Revision 17. The licensee stated that the two conditions placed on the use of N-638-4 by the NRC in RG 1.147 have been addressed in Code Case N-839.

The licensee referenced documents in support of its proposed alternative. Supporting documentation referenced in the submittal includes:

- NRC Regulatory Guide 1.147, Rev. 17, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1." (Reference 1)
- American Society of Mechanical Engineers Code Case N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1." (Reference 2)
- American Society of Mechanical Engineers Code Case N-762, "Temper Bead Procedure Qualification Requirements for Repair/Replacement Activities Without Postweld Heat Treatment, Section XI, Division 1." (Reference 3)
- "Welding and Repair Technology Center: Alternative Rules for Temperbead Qualification." EPRI, Palo Alto, CA: 2012. 1025168. (Reference 4)
- American Society of Mechanical Engineers PVP2012-7B571, "Alternative Approach for Qualification of Temperbead Welding in the Nuclear Industry." (Reference 5)
- "Welding and Repair Technology Center: Shielded Metal Arc Temper Bead Welding." EPRI, Palo Alto, CA: 2015. 3002005536. (Reference 6)

3.1.6 Hardship Justification

The licensee states that performing the Construction Code required preheat and PWHT requires the draining of the component to be repaired. The time needed to drain the component, install the heating elements, establish a preheat, and complete the PWHT results in an increase in the personnel radiation dose. In some instances, isolating and draining a component for repair may not be practical. The licensee stated that meeting the Construction Code requirements for preheat and PWHT would result in hardship without a compensating increase in quality and safety. The licensee further stated that Code Case N-839 provides a technically sound alternative to the Construction Code requirements.

3.1.7 Duration of Relief Request

The licensee requested to apply the proposed alternatives for the NAPS, Units 1 and 2, fourth 10-year ISI intervals. The fourth 10-year ISI interval at NAPS, Unit 1, began on May 1, 2009, and ends on April 30, 2019. The fourth 10-year ISI interval at NAPS, Unit 2, began on December 14, 2010, and ends on December 13, 2020.

3.2 <u>NRC Staff Evaluation</u>

Temper bead welding using the SMAW process has long been permitted in ASME BPV Code, Sections III and XI, with elevated preheat and post weld hydrogen bakeout, to perform weld repairs. Ambient temperature temper bead welding (50 degree F minimum preheat and no

PWHT) has only been available through the use of code cases. Code Case N-638, which permits ambient temperature temper bead welding using the GTAW process, has been used for several years to successfully perform numerous weld repairs at nuclear power plants in the United States. The most recent NRC approved version of Code Case N-638 is Revision 4. As stated by the licensee, the use of Code Case N-638-4 requires considerable pre-planning for effective implementation, which is due to the complexity of the equipment used and the extensive welding operator expertise required. Code Case N-839 provides requirements to perform ambient temperature temper bead welding using the SMAW process. The SMAW process involves the use of relatively unsophisticated equipment and requires substantially less preplanning and set-up time than the use of the machine GTAW process.

The licensee's proposed alternative is to use Code Case N-839 to perform ambient temperature (50 degrees F minimum) temper bead weld repairs, of Class 1, 2 and 3 components, using the SMAW process. Code Case N-839 does not require elevated preheat or PWHT. The proposed alternative includes a restriction on materials that can be welded when using the code case.

Similar to Code Case N-638-4, Code Case N-839 uses the consistent layer temper bead technique (CLTT). In this technique, martensite created in the weld HAZ is tempered by subsequent weld layers, resulting in improved toughness, which must meet the same minimum toughness requirements as those applied to materials that have received a Construction Code required PWHT. The purpose of these two code cases is to permit the welding of carbon and low-alloy steels without elevated preheat or PWHT. The ability to repair materials with a preheat as low as 50 degrees F and without PWHT provides tremendous flexibility, reduces personnel radiation exposure, and permits the repair of components in cases where it is impractical or not possible to perform elevated preheat and PWHT.

Ambient temperature temper bead welding, in accordance with Code Case N-638-4, is an NRC approved alternative when performing weld repairs without elevated preheat or PWHT. Given the extensive history of the successful application of ambient temperature temper bead welding using the GTAW process, the NRC staff focused its review of the current proposed alternative on the differences between Code Case N-638-4 (GTAW) and N-839 (SMAW), as modified by the licensee. The significant differences include: (1) the use of SMAW vs machine GTAW; (2) the restriction on applicable materials that can be repaired when using N-839; (3) use of ASME BPV Code, Section IX, QW-290 to qualify welding procedures and personnel; (4) optional use of simulated PWHT of the procedure qualification test assembly; (5) the use of solid electrodes vs. flux covered electrodes; (6) an alternative option for selection of the procedure qualification CVN test temperature; and (7) N-839 addresses the two NRC conditions placed on the use of Code Case N-638-4. The NRC staff also evaluated the licensee's hardship justification.

3.2.1 SMAW vs GTAW

Machine GTAW provides stricter control over the welding process than the proposed manual SMAW process. However, critical welding process variables for ambient temperature temper bead repairs can be sufficiently controlled using the proposed manual SMAW process to produce a final weld with mechanical properties similar to those achieved when using machine GTAW. It should also be noted that successful completion of the welding procedure qualification confirms that the welding procedure is capable of producing sound welds with adequate mechanical properties and notch toughness. In addition, SMAW temper bead welding with elevated preheat and post weld hydrogen bakeout has been permitted in ASME BPV Code, Sections III and XI, for several years. Therefore, the NRC staff finds that the use of the SMAW process is acceptable to perform ambient temperature temper bead welding.

3.2.2 Applicable Materials

Code Case N-839 and Code Case N-638-4 permit the repair of P-Nos. 1, 3, 12A. 12B, and 12C materials, and their associated welds and welds joining P-No. 8 or P-No. 43 materials to P-Nos. 1, 3, 12A, 12B, and 12c materials, with some limitations when repairing SA 302, Grade B material. The licensee stated that it restricts the applicability of Code Case N-839 so that old P-Nos. 12A, 12B, or 12C materials reclassified to other than P-No. 1 or P-No. 3 (specifically P-Nos. 9A, 98, or 10A) shall not be welded using this alternative. Due to the higher alloy content and hardenability of P-Nos. 9A, 9B, or 10A materials, it is not appropriate, nor the intent of Code Case N-839, to weld materials that were originally classified as P-Nos. 12A, 12B, or 12C and later reclassified as P-Nos. 9A, 98, or 10A. The NRC staff, therefore, finds the licensee's modification to Code Case N-839 acceptable.

3.2.3 Use of QW-290

Code Case N-762 permits the use of ASME BPV Code, Section IX, QW-290 to qualify welding procedures and personnel to perform temper bead welding in lieu of the procedure qualification requirements of Section XI, IWA-4600. Code Case N-762 is approved for use in RG 1.147, Revision 17. Therefore, the NRC staff finds that the use of QW-290, as described in Code Case N-839, is acceptable.

3.2.4 Simulated PWHT

The ASME BPV Code, Sections III and XI, Code Cases N-638-4 and N-762 require, in part, that materials used for weld procedure qualification tests receive a simulated PWHT that is at least equivalent to the time and temperature already applied to the material being welded. Normal industry practice is to submit test assembly materials to sufficiently long PWHT times to envelope as many current and future projects as possible. This results in typically long simulated PWHT times which may far exceed the thermal histories of the materials that will be repaired in the field. Code Case N-839 does not require or prohibit simulated PWHT, however it does limit the time and temperature to that already applied to the materials being repaired. ASME BPV Code, Sections III and XI, and Code Cases N-638-4 and N-839 require that the HAZ CVN average mills later expansion (MLE) value must be equal to or greater than the test plate material. The licensee states that simulated PWHT can degrade the mechanical and impact properties of the test plate material and that meeting the MLE requirement becomes easier when a simulated PWHT is performed. The portion of the HAZ that is heated into the austenite region during welding transforms to predominantly martensite when rapidly cooled. Martensite that is formed in the HAZ is tempered by subsequent welding passes and, as stated above, results in improved notch toughness. Therefore, performing a simulated PWHT of test materials has little or no impact on the HAZ CVN values but can decrease the MLE values of the test plate material. The NRC staff finds that not requiring a simulated PWHT is acceptable because it is more conservative than requiring a simulated PWHT.

3.2.5 Solid vs Flux Coated

Carbon and low alloy steel weld HAZs are potentially susceptible to HIC as a result of hydrogen absorbed into the weld during the welding process. If weld surfaces are cleaned and free of contamination, the primary source of hydrogen absorbed into the weld (diffusible hydrogen) originates from welding consumables. The GTAW uses solid metal filler materials with gas shielding, which is normally 100 percent argon. The shielding gas protects the molten weld pool from the environment. GTAW inherently produces welds with very low diffusible hydrogen levels, normally less than 2 milliliters (ml) per 100 grams (g) of deposited weld metal. The NRC staff is not aware of any HIC that has occurred in repair welds that have been performed in accordance with Code Case N-638. The SMAW consumable electrodes are coated with flux. The flux protects the molten weld pool and also contains alloying elements that are introduced into the weld when the rod core and flux melt during welding. Flux coatings can absorb moisture that can lead to excessive levels of hydrogen absorbed into the weld during the welding process, increasing the potential for HIC. To address the potential for flux coatings to absorb moisture, Code Case N-839 requires the use of electrodes with supplemental designators, R - indicating moisture resistant coatings, and H4 - indicating that they are low diffusible hydrogen (less than 4 ml/100g deposited weld metal). Code Case N-839 also limits the exposure times of various electrode types after removal from sealed packages or rod ovens. Reference 6 of the licensee's November 22, 2016, submittal "Welding and Repair Technology Center: Shielded Metal Arc Temper Bead Welding," documents the results of testing performed on several SMAW electrodes with the R and H4 designators. The testing shows that electrodes exposed to humid environments for the maximum specified exposure times listed in Code Case N-839 result in diffusible hydrogen rates similar to those produced when using the GTAW process with solid filler metals. Based on the above, the NRC staff finds that Code Case N-839 provides adequate requirements to prevent the absorption of hydrogen into the weld from coated electrodes and is, therefore, acceptable. Additionally, in the unlikely event that HIC were to occur, it would most likely occur within 48 hours. Code Case N-839 requires that non-destructive examination of the final weld be performed no sooner than 48 hours after the weld reaches ambient temperature when using ferritic electrodes, or no sooner than 48 hours after completion of the first three temper bead layers when using austenitic weld metal.

3.2.6 Charpy Impact Test Temperature

Qualification test assembly base materials for temper bead welding must meet the impact test requirements of the Construction Code and Owners Requirements. In addition, current ASME BPV Code, Code Case N-638-4, and Code Case N-762 all require, in part, that the average CVN MLE value of the temper bead HAZ is no less than the MLE of the qualification test assembly base material. Code Case N-839 contains the same requirement, however, Code Case N-839 contains additional options to those in the ASME BPV Code testing protocol for determining the CVN testing temperature.

The purpose of the requirement that the average HAZ MLE value is equal to or greater than the base material is to show that the welding procedure does not result in decreased toughness in the portion of the base material that becomes the HAZ. Welding Research Council Bulletin 175 (WRC 175) "PVRC [Pressure Vessel Research Committee] Recommendations on Toughness Requirements for Ferritic Materials," August 1972, explains that since loss of fracture toughness is due to loss in ductility rather than strength, a criterion which evaluates notch ductility rather than energy is a more significant and universal index. An index of ductility can be obtained from CVN test specimens by measuring the lateral expansion of the specimen at the compression side directly opposite the notch (MLE).

The first step of the ASME BPV Code protocol is to determine the nil-ductility transition temperature (T_{NDT}) of the qualification test assembly base material by conducting drop-weight testing. At a temperature of T_{NDT} + 60 degrees F, CVN testing is performed on the base material. If the results of the impacting testing meet ASME BPV Code and the Owners Requirements (e.g., 35 MLE and 50 foot-pounds (ft-lb) of absorbed energy), T_{NDT} is the reference temperature (RT_{NDT}). If the CVN testing values do not meet the requirements, the test temperature is increased until the CVN test results meet the requirements. In this case, RT_{NDT} is defined as the CVN test temperature (where the results meet the 35 MLE and 50 ft-lb of absorbed energy criteria) minus 60 degrees F.

For the HAZ in a welding procedure qualification, the CVN tests at a temperature of T_{NDT} + 60 degrees F must exhibit an average lateral expansion that is no less than that for the qualification test assembly base material. This demonstrates that the welding procedure does not result in decreased toughness in the portion of the base material that becomes the HAZ. If the HAZ MLE does not meet this criterion, then the licensee can requalify the welding procedure or implement an *Adjustment Temperature* for the welding procedure, as described in Section 2.1(e)(8)(-b) of Code Case N-839. In the latter case, as discussed in Reference 5 of the licensee's submittal, applying an *Adjustment Temperature* is not preferred because the minimum specified RT_{NDT} + 60 degrees F (or lowest possible service temperature) would be imposed on the system after temperbead welding and could increase the lowest permissible service temperature.

The origin of the requirements for CVN testing at T_{NDT} + 60 degrees F is described in WRC 175, which shows a correlation between 35 MLE and 50 ft-lb of absorbed energy (at T_{NDT} + 60 degrees) and a dynamic fracture toughness of 70 ksi-$\sqrt{\text{in}}$. This fracture toughness level is squarely in the transition temperature region for the steels covered by WRC 175. Reference 5 of the licensee's submittal, American Society of Mechanical Engineers PVP2012-7B571, "Alternative Approach for Qualification of Temperbead Welding in the Nuclear Industry," notes that the basis for the CVN test requirements in WRC 175 is data from testing performed on A-533-B steel plate materials in the mid to late 1960's. Reference 5 further points out that data for A-508 forging material, which typically has higher fracture toughness properties compared to A-533-B plate, was not included in this correlation and it was assumed at the time that A-508 material would exhibit a similar pattern as A-533-B.

As described in Reference 5, the licensee states that drop weight testing performed on new materials results in a T_{NDT} + 60 degree F temperature that is at the onset of or on the upper shelf in lieu of mid-way in the transition temperature range between the lower shelf and upper shelf. Therefore, it is difficult to show improvement in MLE values of the HAZ compared to the base material in the upper shelf region because the upper shelf MLE is relatively invariant. Reference 5 of the licensee's submittal illustrates this for several CVN curves that show the improvement in MLE values in the HAZ is evident through the transition region up to the upper shelf region as the temperature increases. Conversely, in the upper shelf region, the differences in MLE values of the base material and HAZ become less pronounced and some base material values exceed those for the HAZ, which would result in a failure of the procedure qualification, even though the HAZ would still have a very high toughness as indicated by MLE. As an example, a high HAZ MLE value of 70 would be unacceptable if the base material had a MLE value of 75 MLE. Therefore, the use of a CVN test temperature that is based on T_{NDT} + 60 degrees F may not be an optimum choice to demonstrate the effect of the welding procedure on the HAZ toughness.

As an alternative to the ASME BPV Code protocol for determining the CVN test temperature based on T_{NDT} + 60 degrees F, the licensee proposes to use the alternative criteria in Code Case N-839 that states that the CVN test temperature shall be in the transition temperature range, as determined in accordance with the following: (a) the test temperature for the test assembly base metal shall be derived from the full transition temperature curve in the Certified Material Test Report; (b) a full transition temperature curve for the test assembly base metal shall be developed using CVN testing; or (c) the test temperature shall be in the range where one or more CVN tests in the test assembly base metal exhibit 35 to 50 MLE. The CVN test temperature for the HAZ would then be in the transition temperature range for the test assembly ferritic base metal, permitting a clearer indication if the welding procedure results in decreased toughness for the HAZ.

Based on the above, the NRC staff finds that the Code Case N-839 alternative method to determine the HAZ CVN testing temperature is acceptable because it provides a clear indication of the effect of the welding procedure on the toughness for the HAZ, which is the intent of current ASME BPV Code requirements on weld procedure qualification.

3.2.7 NRC Conditions on Code Case N-638-4

The NRC placed two conditions on the use of Code Case N-638-4 in RG 1.147, Revision 17.

Condition 1 requires that demonstration for ultrasonic examination of the repaired volume is performed using representative samples which contain construction type flaws. Condition 1 is addressed in Section 4(2) of Code Case N-839 that requires the use of representative samples containing construction flaws.

Condition 2 prohibits the use of heat flow calculations or mockup testing to determine weld interpass temperature, in lieu of direct measurement, unless the weld is inaccessible or there are extenuating radiological conditions. Code Case N-839 requires direct measurement of the weld interpass temperature and does not provide any alternative methods.

Based on the above, the NRC staff finds that Code Case N-839 appropriately addresses the conditions placed on Code Case N-638-4 in RG 1.147.

3.2.8 Summary

The NRC staff finds that the proposed alternative provides reasonable assurance of structural integrity and will provide a similar level of quality and safety to ambient temperature temper bead welding performed in accordance with Code Case N-638-4, as approved for use by the NRC staff in RG 1.147.

3.2.9 Hardship Justification

The NRC staff finds that draining of the component and performing the ASME BPV Code required preheat and PWHT would result in increased levels of radiation exposure to plant personnel. Additionally, isolation and draining of components to be repaired may not be feasible. Therefore, the NRC staff finds that compliance with the specified ASME BPV Code repair requirements would result in hardship or unusual difficulty.

4.0 <u>CONCLUSION</u>

As set forth above, the NRC staff determines that the proposed alternative provides reasonable assurance of structural integrity or leak tightness of the subject components, and that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(2). The NRC staff authorizes the use of ASME Code Case N-839, as modified by the licensee, for the fourth 10-year ISI intervals at NAPS, Units 1 and 2.

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

Principal Contributor: R. Davis

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 - PROPOSED ALTERNATIVE TO IMPLEMENT CODE CASE N-839 (CAC NOS. MF8866 AND MF8867) DATED AUGUST 17, 2017

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