This letter forwards proprietary information in accordance with 10 CFR 2.390. The balance of this letter may be considered non-proprietary upon removal of Attachment 5.

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NINE MILE POINT
NUCLEAR STATION

P.O. Box 63
Lycoming, NY 13093

April 9, 2012

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

ATTENTION: Document Control Desk

SUBJECT: Nine Mile Point Nuclear Station
Unit No. 1; Docket No. 50-220

Request to Utilize an Alternative to the Requirements of 10 CFR 50.55a(g) for the Repair of Control Rod Drive Housing Penetrations – Response to NRC Follow-up Request for Additional Information (TAC No. ME5789)

REFERENCES:

(a) Letter from J. E. Pacher (NMPNS) to Document Control Desk (NRC), dated March 25, 2011, Request to Utilize an Alternative to the Requirements of 10 CFR 50.55a(g) for the Repair of Control Rod Drive Housing Penetrations for the Remainder of the License Renewal Period of Extended Operation

(b) Letter from P. M. Swift (NMPNS) to Document Control Desk (NRC), dated September 29, 2011, Request to Utilize an Alternative to the Requirements of 10 CFR 50.55a(g) for the Repair of Control Rod Drive Housing Penetrations – Response to NRC Request for Additional Information (TAC No. ME5789)

(c) Letter from R. V. Guzman (NRC) to K. Langdon (NMPNS), dated February 23, 2012, Request for Additional Information Regarding Nine Mile Point Nuclear Station, Unit No. 1 - Relief Request No. 1ISI-004: Request for Alternative for Repair of Control Rod Drive Housing Penetrations (TAC No. ME5789)

Nine Mile Point Nuclear Station, LLC (NMPNS) hereby transmits supplemental information requested by the NRC in support of a previously submitted request for alternative (No. 1ISI-004) under the provision of 10 CFR 50.55a(a)(3). This 10 CFR 50.55a request, initially submitted in Reference (a), describes an alternative repair strategy for Nine Mile Point Unit 1 Control Rod Drive (CRD) housing penetrations that includes a variation of the CRD housing penetration welded repair geometry specified in Boiling Water Reactor Vessel and Internals Project (BWRVIP) report BWRVIP-58-A and variations from the requirements of the American Society of Mechanical Engineers (ASME) Code, Section XI, and ASME Code Case N-606-1. NMPNS responded to an NRC request for additional information (RAI) by letter

A047
NRR

This letter forwards proprietary information in accordance with 10 CFR 2.390. The balance of this letter may be considered non-proprietary upon removal of Attachment 5.

dated September 29, 2011 (Reference b). The supplemental information, provided in Attachments 1, 3, and 5 to this letter, responds to a follow-up RAI documented in the NRC's letter dated February 23, 2012 (Reference c) that was discussed in telephone conference calls between NRC and NMPNS staff members on January 18, 2012 and February 8, 2012. Revision 1 of 10 CFR 50.55a Request Number 1ISI-004 is provided in Attachment 2.

Attachment 5 is considered to contain proprietary information exempt from disclosure pursuant to 10 CFR 2.390. Therefore, on behalf of AREVA NP, Inc. (AREVA), NMPNS hereby makes application to withhold this attachment from public disclosure in accordance with 10 CFR 2.390(b)(1). The affidavit from AREVA detailing the reasons for the request to withhold the proprietary information is provided in Attachment 4. This submittal contains no new regulatory commitments.

Should you have any questions regarding the information in this submittal, please contact John J. Dosa, Director Licensing, at (315) 349-5219.

Very truly yours,

Paul M. Swift
Manager Engineering Services

PMS/DEV

Attachments:

1. Nine Mile Point Unit 1 – Response to NRC Follow-up Request for Additional Information Regarding 10 CFR 50.55a Request Number 1ISI-004
2. Nine Mile Point Nuclear Station, Unit 1, 10 CFR 50.55a Request Number 1ISI-004, Revision 1
3. White Paper Regarding Peening (Non-Proprietary)
4. Affidavit from AREVA NP Inc. Justifying Withholding Proprietary Information
5. White Paper Regarding Peening (Proprietary)

cc: Regional Administrator, Region I, NRC
Project Manager, NRC
Resident Inspector, NRC

ATTACHMENT 1

NINE MILE POINT UNIT 1

RESPONSE TO NRC FOLLOW-UP REQUEST FOR ADDITIONAL INFORMATION REGARDING 10 CFR 50.55a REQUEST NUMBER 1ISI-004

ATTACHMENT 1

NINE MILE POINT UNIT 1
RESPONSE TO NRC FOLLOW-UP REQUEST FOR ADDITIONAL INFORMATION REGARDING 10 CFR 50.55a REQUEST NUMBER 1ISI-004

By letter dated March 25, 2011, Nine Mile Point Nuclear Station, LLC (NMPNS) submitted 10 CFR 50.55a request number 1ISI-004 pursuant to 10 CFR 50.55a(a)(3). This 10 CFR 50.55a request describes an alternative repair strategy for Nine Mile Point Unit 1 (NMP1) Control Rod Drive (CRD) housing penetrations that includes a variation of the CRD housing penetration welded repair geometry specified in Boiling Water Reactor Vessel and Internals Project (BWRVIP) report BWRVIP-58-A and variations from the requirements of the American Society of Mechanical Engineers (ASME) Code, Section XI, and ASME Code Case N-606-1.

NMPNS responded to an NRC request for additional information (RAI) by letter dated September 29, 2011. This attachment responds to a follow-up RAI documented in the NRC's letter dated February 23, 2012 that was discussed in telephone conference calls between NRC and NMPNS staff members on January 18, 2012 and February 8, 2012. Each individual NRC request is repeated (in italics), followed by the NMPNS response.

RAI - 1

In Proposed Alternative 5A of the submittal, the licensee requested relief from American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4610(a), which requires the use of thermocouples and recording instruments to monitor process temperatures. In RAI-1 of the RAI dated August 11, 2011, the NRC staff requested that the licensee describe how an acceptable level of quality and safety can be maintained in this repair if both heat transfer calculations and temperature measurement on a test coupon are not performed instead of interpass measurement. By letter dated September 29, 2011, the licensee's response stated in part that, "NMPNS will either perform heat flow calculations or measure the maximum interpass temperature on a representative test coupon, but not both. This approach is consistent with the associated requirements specified in American Society of Mechanical Engineers (ASME) Code Case N-638-4, which the NRC has determined to be conditionally acceptable in Regulatory Guide 1.147, Revision 16." As stated in the submittal, and consistent with the "Safety Evaluation Report Related to the License Renewal of Nine Mile Point Nuclear Station, Units 1 and 2" (ADAMS Accession No. ML061460313), the licensee is pursuing a "variation of the welded repair geometry specified in BWRVIP-58-A subject to the approval of the NRC using Code Case N-606-1 in the event that a zero leakage condition is not achieved for a control rod drive (CRD) housing penetration that has been roll-repaired in accordance with the provisions of Code Case N-730." Therefore, the staff review and assessment pertains to ASME Code Case N-606-1; not ASME Code Case N-638-4.

In the RAI response dated September 29, 2011, NMPNS discussed prior work performed by AREVA on pressurized-water reactor (PWR) control rod drive mechanism (CRDM) nozzle penetration modifications which they stated represents a similar configuration to the NMP1 reactor vessel bottom head CRD housing internal weld repair. However, PWR CRDM nozzle penetration modifications and boiling-water reactor (BWR) reactor vessel bottom head CRD housing internal weld repairs have fundamental differences, and any comparison between them must address these differences. For a comparison to be valid, this comparison shall be made on all welds previously repaired without interpass temperature measurement with the current weld to be repaired. The comparison of data from the welding of CRDM nozzles is to include the following for each weld:

a) Thickness of weld and all components joined by it.

b) Types of all materials involved.

c) Welding parameters, i.e., volts, amps, travel speed (heat input) etc.

d) The results of all non-destructive examinations performed on the weld since its original construction to the present day.

e) Any cracks, defects or indications found in the welds since their repair or modification and the analysis of those cracks, defects or indications.

f) A comparison between the operating conditions of each weld and the subject bottom head and CRD housing weld.

g) The length of time that the welds have been in service.

h) A comparison between the actual repairs being performed, using drawings of each weld and the subject bottom head and CRD housing weld. The comparison shall include temperature comparisons between the temperatures measured on the mockup and the calculated temperature.

Include all welds repaired without interpass temperature measurement in this data. Staff requests that this data and comparison be submitted to the NRC for review.

Response

After further consideration, NMPNS has determined that both heat flow calculations and measurement of interpass temperature on a test coupon will be performed, in lieu of using thermocouples and recording instruments to monitor process temperatures during the actual welding operations. This is consistent with the NRC's suggestion in RAI-1 of their letter dated August 11, 2011. Proposed Alternative 5A has been revised accordingly, as shown in Revision 1 of 10 CFR 50.55a Request Number 1ISI-004 provided in Attachment 2.

RAI - 2

In Proposed Alternative 6A of the submittal, the licensee requested relief from ASME Code Case N-606-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique for BWR CRD Housing Stub Tube Repairs," Section XI, Division 1, Paragraph 1(f) which prohibits peening of the final weld layer. Peening is a process which can crack or otherwise damage welds. It can also mask nondestructive examination methods from identifying defects in a weld. If peening is performed on a weld, the potential for creating or masking defects exists. The stress profile of the peened surface is unknown; and the effect of peening on the mechanical and other properties, such as, fatigue, corrosion or stress-corrosion cracking is unknown. The prohibition of peening of the final weld surface is contained in Paragraph 1(f) of ASME Code Case N-606-1 as stated above and also in *paragraph NB-4422 of ASME Section III. There is no precedent of rotary peening of the final weld layer of a BWR CRD housing.*

In order to adequately evaluate a deviation from the ASME Code, a rigorous technical basis would need to be submitted for NRC Staff review in order to evaluate the process of rotary peening of the final weld layer of a BWR CRD housing. This technical basis should be sufficiently detailed to potentially justify a deviation to the ASME Code (i.e., an ASME white paper).

Response

NMPNS has prepared a white paper, provided in Attachment 3 (Non-Proprietary) and Attachment 5 (Proprietary), that discusses peening in general and the Roto-peening process that is specifically proposed for use on the NMP1 CRD housing penetration weld repair. The Roto-peening process is a controlled peening method that effectively induces consistent surface compressive residual stresses in a weld-repaired component. The removal of tensile stress at the surface through the creation of a shallow layer under compressive stress effectively mitigates the formation of stress corrosion cracks in stainless steel weldments and associated heat affected base materials. As discussed in Attachments 3 and 5, the Roto-peening process does not damage the weld or produce surface defects, and non-destructive examination performed prior to Roto-peening will ensure that surface defects will not be masked. Based on the information provided in Attachments 3 and 5, NMPNS concludes that the Roto-peening process has significant beneficial stress improvement effects, and that Proposed Alternative 6A (requesting relief from the restriction stated in Paragraph 1(f) of ASME Code Case N-606-1) is technically justified.

RAI - 3

RAI-3 of the RAI letter dated August 11, 2011, referenced the original submittal which stated, in part that, "in the event that roll expansion does not seal the [Control Rod Drive Housing] penetration and stop the leak, a repair shall be performed based on BWRVIP-58-A as depicted in Figure 1 with variations thereto as discussed and justified herein." Section 3 of BWRVIP-58-A, "BWR Vessel and Internals Project, CRD Internal Access Weld Repair," discusses repair of CRD welds. Section 3.3 of BWRVIP-58-A discusses making a weld repair if water is leaking through a crack and states that, "the welding is performed at a pressure (~60 pounds per-square-inch) that would prevent leakage of water into the cavity during the welding process. The pressure in the cavity is maintained during the welding process by sealing at the CRD housing flange and at the nozzle bore plug. This hyperbaric-chamber environment must be maintained during an initial drying cycle when any residual moisture from the AWJ [Abrasive water jet] process or leakage is removed, and during the first three layers of welding to insure the leak path is sealed."

If this process or any other similar process is performed, then this weld is a dry underwater weld, and as such, the rules of ASME Code, Section XI, IWA-4660, "Underwater Welding" apply. The rules of Title 10 of the Code of Federal Regulations (10 CFR) 50.55a(b)(2)(xii) also apply, in which case permission to perform underwater welding must be sought from the NRC.

In its RAI response dated September 29, 2011, NMPNS concluded that the NMP1 CRD housings may be considered non-irradiated material for the purpose of the proposed weld repair, and that a request for relief from the requirements of 10 CFR 50.55a(b)(2)(xii) is not required. Since there is a radiation field *at the bottom of the vessel, a request for relief is required to be submitted, and as part of the request, the licensee must provide the accumulated dose at the weld.*

Response

The NRC regulations at 10 CFR 50.55a(b)(2)(xii) state:

> "The provisions in IWA–4660, "Underwater Welding," of Section XI, 1997 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, are not approved for use on irradiated material."

The rule concerning underwater welding was initially proposed (using different language) on August 3, 2001 (66 FR 40626), and was issued as a final rule on September 26, 2002 (67 FR 60520). As indicated in the supplementary information associated with both the proposed and final rule, the concern being addressed by the rule is that underwater weld repairs using conventional welding techniques on reactor vessel components exposed to high neutron fluences may be unsuccessful due to helium-induced cracking and radiation damage, unless special welding techniques are used. The stated intent of the rule is to require licensees to obtain NRC approval of the technique used to weld such irradiated material underwater.

In BWRVIP-97-A, "Guidelines for Performing Weld Repairs to Irradiated BWR Internals," a generic weldability boundary is established. Within this boundary, BWRVIP-97-A states that the effects of irradiation are benign, and that welding may be performed by conventional means without regard for the effects of irradiation. NRC acceptance of BWRVIP-97-A is documented in the NRC safety evaluation transmitted to the BWRVIP by NRC letter dated June 30, 2008. In addition, American Society of Mechanical Engineers (ASME) Code Case N-606-1, Section 2.1(c), states the following:

> "Consideration shall be given to the effects of irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel."

The NMP1 CRD housing penetrations are located at the bottom of the reactor vessel, approximately 14 feet or more below the core belt line region, and are well within the generic weldability boundary established in BWRVIP-97-A.

The NMP1 reactor vessel neutron fluence calculations use methodology that is in accordance with the guidance contained in Regulatory Guide 1.190, "Calculation and Dosimetry Techniques for Determining Pressure Vessel Neutron Fluence." By letter dated October 27, 2003 that issued NMP1 License Amendment No. 183, the NRC documented their determination that the NMPNS neutron fluence calculation methodology was acceptable. The current updated fluence calculations do not specifically predict the neutron fluence at the bottom of the reactor vessel; however, they do predict the following fluence values for 46 Effective Full Power Years (EFPY) of exposure (i.e., up to or beyond the end of the renewed facility operating license):

Location	Predicted Neutron Fluence, 46 EFPY exposure, E > 1Mev (n/cm^2)
Core shroud weld H5, located 32.3 inches above the bottom of active fuel (BAF); i.e., in the core belt line region	5.70E20
Core shroud weld H6A at the shroud lower ring, 31.2 inches below BAF	2.48E17
Core shroud weld H7 at the shroud support ring, 57.8 inches below BAF	1.45E15

These calculations demonstrate that the neutron fluence decreases significantly as distance from the BAF increases. The CRD housing penetration nearest to the bottom of active fuel is 185 inches (15.4 feet) below BAF and approximately 128 inches (10.7 feet) below the location of core shroud weld H7. Considering attenuation through the intervening water and reactor vessel mid-wall existing between the H7 core shroud weld elevation and the CRD housing penetrations, the accumulated neutron fluence at the location of the CRD housing penetrations for 46 EFPY of exposure is estimated to be several orders of magnitude less than 1.45E15 n/cm^2 (E > 1 MeV).

Based on the above, NMPNS concludes that the NMP1 CRD housing penetration materials are not highly irradiated and that the weld repair can be performed using conventional welding techniques without consideration of the effects of irradiation on the properties of the involved materials. Therefore, a request for relief from the requirements of 10 CFR 50.55a(b)(2)(xii) for the purpose of obtaining NRC approval of a technique used to weld highly irradiated material underwater is not required.

ATTACHMENT 2

NINE MILE POINT NUCLEAR STATION, UNIT 1

10 CFR 50.55a REQUEST NUMBER 1ISI-004, REVISION 1

Note: The Revision 1 changes are indicated by vertical bars drawn in the right hand margin of affected pages.

Proposed Alternative
In Accordance with 10 CFR 50.55a(a)(3)(i)

A. COMPONENT IDENTIFICATION:

System: Control Rod Drive (CRD) Bottom Head Penetrations

Code Class: Quality Group A, ASME Code Class 1

Description: Penetrations for the CRD housings are located in the lower head of the reactor vessel (RV). Stainless steel stub tubes are welded to the penetrations and CRD housings are welded to the stub tubes. The general configuration of the CRD housing penetrations is shown in Figure 1, and the component materials are summarized in Table 1.

Components Affected: RV Bottom Head and CRD Housing Penetrations

TABLE 1 – MATERIALS

Vessel Bottom Head	CRD Housing	Stub Tube	CRD Housing-to-Stub Tube Weld
SA-302, Gr. B	SA-312 or SA-376, TP304	SA-182, F304	308 or 308L

B. APPLICABLE CODE REQUIREMENTS:

The reactor pressure boundary was designed and certified in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Sections I and VIII, 1959 Edition with Addenda through Winter 1963, and ASME Code Cases 1270N and 1273N. The CRD housing was designed to ASME Code Section III, 1965 Edition, no Addenda.

ASME Code, Section XI, 2004 Edition, no Addenda (Reference 1), is applicable for repair/replacement activities for the Nine Mile Point Unit 1 (NMP1) fourth 10-year inservice inspection (ISI) interval. The fourth 10-year ISI interval began on August 23, 2009, concurrent with the NMP1 license renewal period of extended operation.

ASME Code Case N-606-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique for BWR CRD Housing/Stub Tube Repairs" (Reference 2), provides requirements for automatic or machine Gas Tungsten-Arc Welding (GTAW) of Class 1 components without the use of preheat or post-weld heat treatment. The technique described in the Code Case is applicable for welding on ferritic low alloy steel, with the condition specified in Regulatory Guide (RG) 1.147, Revision 16 (Reference 3).

The following are specific code requirements that pertain to this 10 CFR 50.55a request.

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4221(a) states:

  "An item to be used for repair/replacement activities shall meet the Owner's Requirements. Owner's Requirements may be revised, provided they are reconciled in accordance with IWA-4222. Reconciliation documentation shall be prepared."

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4221(b) states:

  "An item to be used for repair/replacement activities shall meet the Construction Code specified in accordance with (1), (2), or (3) below."

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4221(c) states in part:

  "As an alternative to (b) above, the item may meet all or portions of the requirements of different Editions and Addenda of the Construction Code, or Section III when the Construction Code was not Section III, provided the requirements of IWA-4222 through IWA-4226, as applicable, are met. ....."

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4400 provides welding, brazing, metal removal, and installation requirements related to repair/replacement activities.

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4411 states:

  "Welding, brazing, and installation shall be performed in accordance with the Owner's Requirements and, except as modified below, in accordance with the Construction Code of the item."

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4411(a) states in part:

  "Later editions and addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used provided the substitution is as listed in IWA-4221(c). ....."

- ASME Code Section XI, 2004 Edition, no Addenda, IWA-4610(a) states in part:

  "... Thermocouples and recording instruments shall be used to monitor the process temperatures. ..."

- ASME Code Section III, 2004 Edition, no Addenda, NB-5331 states:

  "All imperfections which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of acceptance standards given in (a) and (b) below."

- ASME Code Section III, 2004 Edition, no Addenda, NB-5331(b) states:

  "Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length."

- Code Case N-606-1, paragraph 1(f) states:

  "Peening may be used, except on the initial and final layers."

- Code Case N-606-1, paragraph 3(d) states:

  "The maximum interpass temperature for field applications shall be 350°F regardless of the interpass temperature during qualification."

- Code Case N-606-1, last sentence in the "*Reply*" states in part:

  "... welds, may be made by the automatic or machine GTAW temper bead technique...., and without the nondestructive examination requirements of the Construction Code, provided the requirements of para. 1 through para. 5, and all other requirements of IWA-4000, are met."

- Code Case N-606-1, paragraph 4(a) states:

  "The final weld surface and the band around the area defined in para. 1(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."

C. REASON FOR REQUEST FOR RELIEF:

Stainless steel stub tubes were welded to the RV bottom head during shop fabrication of the RV. The RV bottom head was subjected to post weld heat treatment at some point after the stub tubes were welded therein. As a result of the post weld heat treatment, the stainless steel stub tubes became furnace sensitized and therefore susceptible to intergranular stress corrosion cracking (IGSCC). A number of CRD housing penetrations have developed leaks due to IGSCC of the furnace sensitized stainless steel and/or the Alloy 82/182 stub tube-to-vessel weld.

The NRC staff informed Nine Mile Point Nuclear Station, LLC (NMPNS) during the License Renewal Application process that the staff did not consider the then-applicable plant-specific roll repair process to be acceptable for permanent repair of leaking CRD penetrations (Reference 4). As a result, NMPNS committed to implement ASME Code Case N-730, "Roll-Expansion of Class 1 Control Rod Drive Bottom Head Penetrations in BWR's, Section XI, Division 1," during the license renewal period, which began August 23, 2009. NMPNS requested relief to use Code Case N-730, and the NRC approved the request by their letter dated August 3, 2009 (Accession No. ML091980454).

Roll expansion repair is the preferred strategy for the license renewal period to maintain zero leakage at CRD penetrations. However, the license renewal commitment also stated that during the period of extended operation, should a CRD housing penetration (stub tube) rolled in accordance with the provisions of the Case N-730 resume leaking, NMPNS will implement a zero leakage permanent repair prior to startup from the outage in which the leakage was detected. The permanent repair selected by NMPNS will consist of a variation of the welded repair geometry specified in BWRVIP-58-A (Reference 5) using Code Case N-606-1, as endorsed by the NRC in RG 1.147. The ambient temperature inside diameter temper bead (IDTB) welding method will be used to restore the pressure boundary of the CRD penetration(s). The IDTB welding method is performed with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and ambient preheat temperature temper bead method with 50°F minimum preheat temperature and no post weld heat treatment. The repair will be conducted in accordance with ASME Section XI, 2004 Edition, no Addenda, Code Case N-606-1, and the alternative requirements discussed below. The repair will seal a leaking CRD housing penetration and provide a new reactor coolant system (RCS) pressure boundary weld, as shown in Figure 2.

Pursuant to 10 CFR 50.55a(a)(3)(i), NMPNS requests approval to vary from the requirements of ASME Section XI and Code Case N-606-1 described in Section B above. The proposed alternative requirements and associated justifications are described in Section D below. NMPNS has determined that the proposed alternative provides an acceptable level of quality and safety and satisfies the requirements of 10 CFR 50.55a(a)(3)(i).

D. BASIS FOR RELIEF AND ALTERNATIVE EXAMINATIONS:

The proposed alternative described in this section involves the implementation of an IDTB weld repair of CRD housings at NMP1 that is similar to the internal access weld repair described in BWRVIP-58-A. The purpose of the repair is to provide a new RCS pressure boundary weld, utilizing weld material that is highly resistant to IGSCC. BWRVIP-58-A documents the development, qualification, and demonstration of an internal access weld repair for a leaking CRD housing. The NRC staff has reviewed BWRVIP-58-A and determined that the report is acceptable for providing guidance for the repair of CRD housing penetration welds inside the RV (Reference 6).

In accordance with 10 CFR 50.55a(a)(3)(i), NMPNS proposes to implement an IDTB weld repair using Code Case N-606-1, with the condition specified in RG 1.147, Revision 16, and the alternate provisions described below.

1A. Proposed Alternative: Acceptance Examination Area

Code Case N-606-1, Paragraph 4(a), requires the final weld surface and the preheated band around the area defined in paragraph 1(d) to be examined using surface and ultrasonic methods.

NMPNS requests relief from examination of the area defined in Code Case N-606-1, Paragraph 4(a). In lieu of Code Case N-606-1 Paragraph 4(a), final examination of the new weld and immediate surrounding area within the bore will be performed. The nondestructive examination (NDE) volumes and areas will be similar to those described in BWRVIP-58-A, as discussed in Attachment 2.

Figure 2 depicts the areas for liquid penetrant (PT) examination and ultrasonic examination (UT) of the modified CRD penetration.

1B. Basis for Relief:

Code Case N-606-1, Paragraph 1(d), defines the area to be welded and the band around the area (at least 1½ times the component thickness or 5 inches, whichever is less) to be preheated. The band around the repair weld area, as defined in Code Case N-606-1, Paragraph 1(d), cannot be examined as specified in Code Case N-606-1, Paragraph 4(a). Access restrictions and the final configuration of the repair weld do not allow UT examination or PT examination of the ferritic steel 5 inch band. This is illustrated in Figures 1 and 2, which show that the surface of the ferritic steel vessel bottom head penetration is blocked by the CRD housing and the completed weld, such that access for PT examination and UT examination of the vessel surface is not possible.

The band includes an annular area extending 5 inches above and below the area to be welded in the penetration bore that extends onto the outside surface of the RV bottom head. This examination requirement was intended for situations wherein the original flaw creating the leak path is being repaired and it is necessary to confirm complete removal of the original flaw. For the proposed weld repair method, the original flaw remains as-is and the repair creates a new pressure boundary weld remote from the original flaw locations.

The exposed ferritic steel portion of the CRD housing penetration at the root of the repair weld and the weld preparation bevel on the end of the remaining portion of the CRD housing lower section are PT examined prior to welding. This examination provides assurance that no flaws exist on the surfaces in the bore in the region to be welded.

The final examination of the new weld and immediate surrounding area within the bore will be sufficient to verify that defects have not been induced in the low alloy steel bottom head material due to the welding process and will assure the integrity of the CRD housing and the new weld. Figure 2 depicts the areas for PT examination and UT examination of the modified CRD housing penetration. The PT area includes the new weld surface and ½ inch minimum distance below the weld. UT will be performed by scanning from the inner diameter (ID) surface of the CRD housing and weld. The UT examination is qualified to detect flaws in the new weld and base metal interface beneath the new weld. UT acceptance criteria are in accordance with NB-5331, as modified by BWRVIP-58-A. The extent of the examination is consistent with Construction Code requirements. The volume of interest for UT examination includes the new weld, the bottom head low alloy steel base material heat affected zone (HAZ), the CRD housing to weld interface, and the CRD housing base material beneath the weld. Limited UT coverage of the low alloy steel volume beneath the weld taper or the weld taper volume can be accomplished due to the weld geometry and the ultrasonic beam angles that are used for examination.

The basis for excluding surface and volumetric examination of the region around the final weld surface is BWRVIP-58-A, which has been approved by the NRC. The NDE procedures were developed and demonstrated to provide an acceptable level of quality for the CRD internal access weld repair. The alternative proposes to perform similar NDE as was approved in BWRVIP-58-A (see Attachment 2).

2A. Proposed Alternative: 48-Hour Hold

Code Case N-606-1, Paragraph 4(a), requires the surface and volumetric examinations to be performed at least 48 hours after the completed weld has been at ambient temperature.

NMPNS requests relief from the 48-hour hold defined in Code Case N-606-1, Paragraph 4(a). In lieu of the Code Case N-606-1, Paragraph 4(a) requirement, the final examination of the new weld and immediate surrounding area within the bore will occur at least 48 hours after the completion of the third temper bead layer.

2B. Basis for Relief:

Hydrogen cracking is a form of cold cracking. It is produced by the action of internal tensile stresses acting on low toughness material weld heat affected zones. The internal stresses are produced from localized build-ups of monatomic hydrogen. Monatomic hydrogen forms when moisture or hydrocarbons interact with the welding arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen recombines to form molecular hydrogen, thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen induced cracking occurs. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and typically occurs within 48 hours of welding.

The machine GTAW process is inherently free of hydrogen. Unlike the shielded metal arc welding process, GTAW filler metals do not rely on flux coverings that may be susceptible to moisture absorption from the environment. The GTAW process utilizes dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded is vaporized ahead of the welding torch. The vapor is prevented from being mixed with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce weld wires having very low residual hydrogen. This is important because filler metals and base materials are the most realistic sources of hydrogen for the automatic or machine GTAW temper bead process. Therefore, the potential for hydrogen-induced cracking is greatly reduced by using the machine GTAW process. Extensive research has been performed by the Electric Power Research Institute (EPRI). EPRI Report 1013558, "Repair and Replacement Applications Center: Temperbead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding" (Reference 7) provides justification for starting the 48-hour hold after completing the third temper bead weld layer rather than waiting for the weld overlay to cool to ambient temperature.

3A. Proposed Alternative: Acceptance NDE

Code Case N-606-1, Paragraph 4(a), requires UT examination to be in performed in accordance with Appendix I, and Paragraph 4(d) specifies acceptance criteria in accordance with ASME Code Section XI, IWB-3000.

IWB-3000 does not have any acceptance criteria that directly apply to the partial penetration weld configuration. Therefore, NMPNS requests relief from examination requirements as specified in Code Case N-606-1 Paragraphs 4(a) and 4(d). The alternative proposes to perform NDE in accordance with ASME Code Section III similar to that specified in BWRVIP-58-A (see Attachment 2), except that the 2004 Edition with no Addenda (Reference 8) will be used in lieu of the 1995 Edition, including Addenda through 1995 (Reference 9).

3B. Basis for Relief:

The acceptance criteria of NB-5331 in ASME Code Section III, 2004 Edition with no Addenda, will apply to all flaws identified within the new weld volume, as modified by and similar to that specified in BWRVIP-58-A.

Section III, NB-5245 requires incremental and final surface examination of partial penetration welds. Due to the welding layer disposition sequence (i.e., each layer is deposited parallel to the penetration centerline), the specific requirements of NB-5245 cannot be met. The Construction Code requirement for progressive surface examination is because volumetric examination is not practical for conventional partial penetration weld configurations.

The new weld is suitable for UT examination, and a final surface PT examination will be performed. UT examination will be performed by scanning from the inner diameter surface of the housing and weld. The UT examination is qualified to detect flaws in the new weld and base metal interface beneath the new weld. UT examination acceptance criteria are in accordance with NB-5331 as modified by BWRVIP-58-A. The extent of the examination is consistent with Construction Code requirements and similar to that specified in BWRVIP-58-A, as discussed in Attachment 2.

The volume of interest for UT examination, which will be covered to the maximum extent practical, includes the new weld, the bottom head low alloy steel base material heat affected zone beneath the weld, the CRD housing to weld interface, and the CRD housing base material beneath the weld. Limited UT coverage of the low alloy steel volume beneath the weld taper or the weld taper volume can be accomplished due to the weld geometry and the ultrasonic beam angles that are used for examination.

The final examination of the new weld and immediate surrounding area will be sufficient to verify that defects have not been induced in the ferritic low alloy reactor vessel bottom head due to the welding process. UT examination will be performed by scanning from the ID surface of the weld and the adjacent portion of the CRD housing. The UT examination is qualified to detect flaws in the new weld and base metal interface in the modified configuration, to the maximum extent practical.

4A. Proposed Alternative: Triple Point Anomaly

UT examination is proposed to be performed in accordance with ASME Code Section III, 2004 Edition with no Addenda, as modified by and similar to that specified in BWRVIP-58-A (see Proposed Alternative 3A above). ASME Section III NB-5330 acceptance criteria (see Section B above) apply, including NB-5331(b), which states that indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

As discussed in BWRVIP-58-A, in some cases a solidification anomaly has been observed at the weld root and may be detected when performing the UT examination. Analyses described in BWRVIP-58-A concluded that these anomalies are not detrimental to the repair weld design if they are less than 0.05 inches extending from the triple point. NMPNS requests relief to permit anomalies in the weld not exceeding 0.10 inches long for the full circumference at the triple point. If these anomalies are determined to be less than or equal to 0.10 in. long emanating in any direction from the weld root triple point and extending around the penetration for the full circumference or less, they will be acceptable and repair will not be required.

4B. Basis for Relief:

An artifact of the ambient temperature temper bead repair weld is an anomaly in the weld at the triple point. The triple point is where there is a confluence of three materials: the stainless steel CRD housing, the stainless steel weld, and the low alloy steel RV bottom head. The location of the triple point anomaly is shown in Figure 2. This anomaly consists of an irregularly shaped very small void. Mock-up testing has verified that the anomalies may exist and do not exceed 0.10 inch in length.

A fracture mechanics analysis has been performed to provide justification, in accordance with the ASME Code Section XI, for operating with the postulated triple point anomaly. The anomaly is modeled as a 0.10 inch, "crack like" defect, extending 360° around the circumference at the triple point location. The analysis includes a prediction of fatigue crack growth in an air environment, since the anomaly is located on the outside surface of the new weld. Several potential flaw propagation paths are considered in the flaw evaluation. The results of the analysis demonstrate that the 0.10 inch weld anomaly is acceptable. In accordance with ASME Section XI, IWB-3134(b), the results of the analysis are provided in Attachment 3 (non-proprietary) and Attachment 5 (proprietary).

5A. Proposed Alternative: Interpass Temperature Monitoring

ASME Code Section XI, IWA-4610(a), requires the use of thermocouples and recording instruments to monitor process temperatures.

NMPNS requests relief from using thermocouples for interpass temperature monitoring as specified in IWA-4610(a). In lieu of using thermocouples to monitor and verify process temperatures, maximum interpass temperature verification is proposed to be accomplished by performing heat transfer calculations and by performing temperature measurement on a test coupon that is no thicker than the bottom head and CRD housing wall thickness. The test coupon welding will use the maximum heat input permitted by the applicable welding procedure specification.

5B. Basis for Relief:

Direct interpass temperature measurement is impractical to perform during welding operations from inside the CRD housing penetration bores. Interpass temperature measurements cannot be accomplished due to the physical configuration and the inaccessibility of the weld region during welding.

For this repair, the maximum interpass temperature will be determined by both of the following methods:

(1) Heat-flow calculations, using at least the variables listed below:
  (a) Welding heat input
  (b) Initial base material temperature
  (c) Configuration, thickness, and mass of the item being welded
  (d) Thermal conductivity and diffusivity of the materials being welded
  (e) Arc time per weld pass and delay time between each pass
  (f) Arc time to complete the weld

(2) Measurement of the maximum interpass temperature on a test coupon that is no thicker than the item to be welded. The maximum heat input of the welding procedure shall be used in welding the test coupon.

These methods are consistent with the associated requirements specified in Code Case N-638-4. Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 16, dated October 2010, lists ASME Code Case N-638-4 as a conditionally accepted ASME Code Section XI code case. The approval conditions noted in the regulatory guide do not impact requirements for performing maximum interpass temperature verification as described in Code Case N-638-4 and herein. Use of the two methods provides adequate assurance that interpass temperatures will remain below 350°F.

6A. Proposed Alternative: Rotary Peening

Code Case N-606-1, Paragraph 1(f), prohibits peening of the final weld layer.

NMPNS requests relief from this restriction to allow portions of the final weld surface and the heat affected zone in the lower CRD housing to be rotary peened after acceptance NDE has been performed. The rotary peening process will decrease the susceptibility of the weld and adjacent stainless steel CRD housing base material heat affected zone to intergranular stress corrosion cracking (IGSCC).

6B. Basis for Relief:

Stainless steel is particularly susceptible to IGSCC in the CRD housing weld heat affected zone due to the potential for sensitization and high residual stresses from welding. The CRD housing is Type 304 stainless steel with a maximum allowable carbon content of 0.08 wt% and thus the heat-affected zone due to the repair weld is susceptible to sensitization. Tensile residual stresses created during welding are minimized by controlling the heat input. After welding and machining, the CRD housing heat affected zone exposed to the BWR environment will undergo a rotary peening remediation process to create a layer of compressive stress at the surface. The vertical face of the weld will also be subjected to the rotary peening.

X-ray diffraction testing of a mock-up of the proposed CRD housing repair was performed to determine the depth of the peening effects and to confirm the presence of residual compressive surface stresses in the CRD housing heat affected zone. Additionally, boiling magnesium chloride testing performed during qualification testing confirmed that the residual compressive stresses were sufficient to prevent IGSCC in the CRD housing heat-affected zone. Micro-hardness testing in the stainless steel weld metal and the stainless steel base material was also used to demonstrate the effectiveness of the rotary peening process. X-ray diffraction testing of the rotary peened mockup samples, one thermally aged and one not subjected to thermal aging, verified that the imparted residual compressive stresses are not significantly reduced due to BWR operating conditions.

E. IMPLEMENTATION SCHEDULE:

Pursuant to 10 CFR 50.55a(a)(3)(i), NMPNS requests relief for the remaining term of the NMP1 renewed operating license, which expires on August 22, 2029. NMPNS has demonstrated that the criteria specified herein provide an acceptable level of quality and safety and therefore, the requested duration of the proposed alternative is justified.

F. PRECEDENTS:

Many precedents similar to that proposed for use at NMP1 on the use of the ambient temperature temper bead weld repair of control rod drive mechanism (CRDM) penetrations have occurred in the industry for pressurized water reactor (PWR) closure heads. A recent safety evaluation report (SER) was issued to Palisades Nuclear Plant (Accession No. ML060790061) and encompassed inspection limitations of the base metal adjacent to the new repair weld. Precedents for starting the 48-hour hold after the third temper bead layer have been established by various weld overlays, as documented in the SERs issued for San Onofre, Units 2 & 3 pressurizer surge line nozzle overlay relief request (ML073240437); Palo Verde, Units 1, 2, & 3 pressurizer spray, safety, and surge line nozzle overlays (ML071560008); and Diablo Canyon, Unit 2, pressurizer safety and surge line nozzle overlays (ML080110001).

G. REFERENCES:

1. ASME Boiler and Pressure Vessel Code, Section XI, 2004 Edition, no Addenda
2. Code Case N-606-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique for BWR CRD Housing/Stub Tube Repairs," dated September 24, 1999
3. Regulatory Guide 1.147, Revision 16, Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1, October 2010
4. Letter from N. B. Le (NRC) to J. A. Spina (NMPNS), "Request for Additional Information for the Review of Nine Mile Point Nuclear Station, Units 1 and 2, Amended License Renewal Application (TAC Nos. MC3272 and MC3273)," dated November 2, 2005.
5. BWRVIP-58-A, "BWR Vessel and Internals Project, CRD Internal Access Weld Repair," EPRI, Palo Alto, CA, October 2005. 1012618
6. NRC Approval Letter for BWRVIP-58-A, "BWR Vessel and Internals Project, CRD Internal Access Weld Repair," dated March 10, 2006
7. EPRI Report 1013558, "Repair and Replacement Applications Center: Temperbead Welding Applications, 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding," EPRI, Palo Alto, CA: 2006. (Accession No. ML070670060)
8. ASME Boiler and Pressure Vessel Code, Section III, 2004 Edition, no Addenda
9. ASME Boiler and Pressure Vessel Code, Section III, 1995 Edition, including Addenda through 1995

Figure 1 – Typical CRD Housing/Stub Tube Configuration

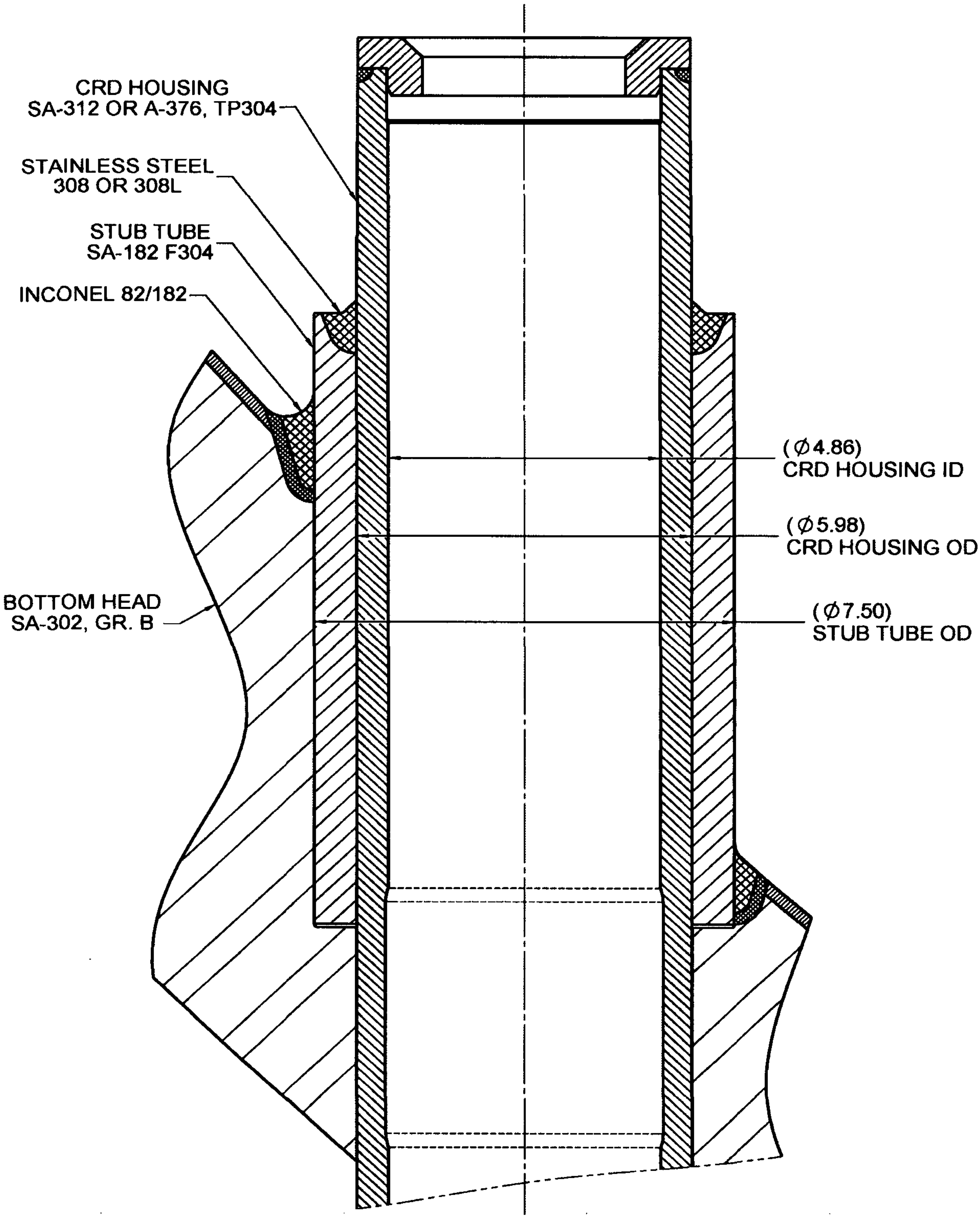
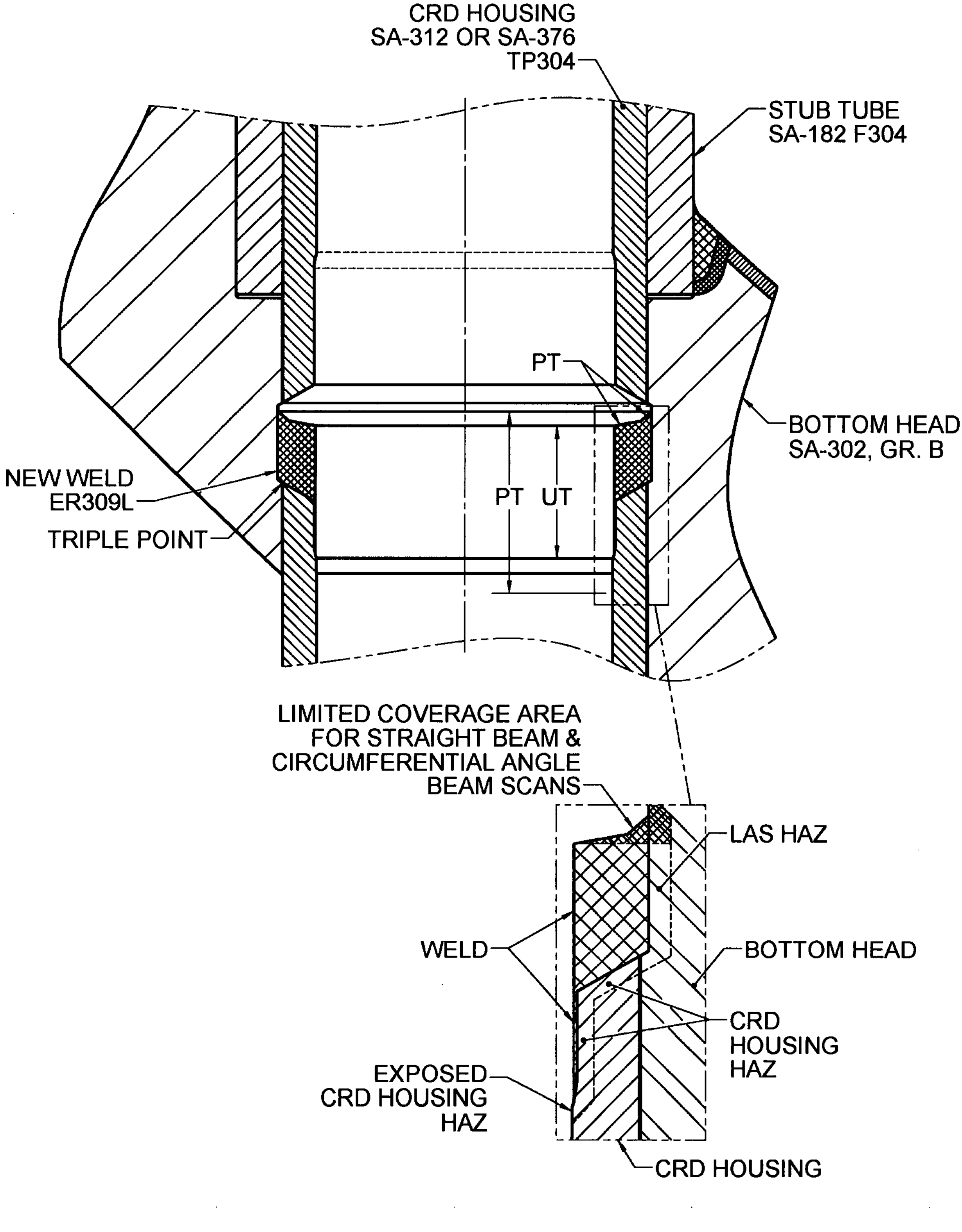


Figure 2 – Modified CRD Housing



ATTACHMENT 3

WHITE PAPER REGARDING PEENING (NON-PROPRIETARY)

White Paper Regarding Peening

Executive Summary

- The term, "peening", as prohibited in the American Society of Mechanical Engineers (ASME) Code Case N-606-1, Paragraph 1(f) and in the ASME Code, Section III, NB-4422, refers to a crude, manual process, using tools such as a rounded air chisel. The process was mainly used for dimensional or distortion control many years ago but due to the Code prohibition, is rarely used in the current nuclear industry. This form of peening puts large localized and non-uniform residual stresses on the weld joint and, as pointed out by the NRC, can crack or otherwise damage welds and/or mask surface defects. In contrast, controlled peening methods, such as the Roto-peening as proposed by Nine Mile Point Nuclear Station, LLC (NMPNS) for use on the Nine Mile Point Unit 1 (NMP1) control rod drive (CRD) housing penetration repair weld and heat affected zone are modern, sophisticated, controlled processes that impart uniform (in magnitude and coverage) compressive stresses on the target surface. The influence of Roto-peening on the residual stress only persists to about [[ ]] of an inch below the surface.

- The ASME Code Section III, Appendix W, Article W-2000, Section W-2140, clearly describes the beneficial nature of compressive stresses for the mitigation of stress corrosion cracking (SCC) susceptibility. It states that shot peening, as a form of stress improvement, can be used to place the inside diameter of piping in a compressive residual stress state to resist SCC. NMPNS will be using Roto-peening, a variant of shot peening, for the CRD housing penetration repair. With Roto-peening, the shot is captured in a flap and regularly spaced such that it uniformly imparts compressive stresses on the surface of metal components.

- Unlike ASME Section III and Code Case N-606-1, the main body of ASME Section VIII, Division 1 (Section UW-39) currently makes the distinction between conventional peening and controlled peening approaches, prohibiting the former and permitting the latter on the final weld layer.

- Shot peening of metal parts is a mature and accepted industrial process commonly used in the aerospace, defense, automotive, and other industries to significantly improve fatigue properties and mitigate SCC susceptibility. There have been many studies performed to characterize the residual stress profile and the beneficial effects of controlled peening on fatigue, corrosion and SCC. In particular, for the NMP1 CRD housing penetration repair application, the residual stress magnitude as a function of depth is not an unknown and was measured by the standard X-Ray diffraction method on several full-scale mock-up samples using the same Roto-peening parameters as those to be used on actual CRD housing repairs. On these samples, the improved resistance to SCC as compared to an unpeened sample, and thermal stability after a heat treatment cycle, were demonstrated. Although application of controlled peening methods to boiling water reactor (BWR) CRD housing penetrations has not been used in the United States, controlled peening has become standard practice in Japan for new construction and has been applied to several existing plants. The use of Roto-peening using captured shot overcomes two limitations of conventional shot peening, namely access to small areas and control of the shot media.

Background – Distinction Between 'Crude' Peening and Stress Improvement Peening

The term "peening" in current usage refers to a myriad of processing methods applied to welds to achieve various purposes. These methods vary drastically over a wide spectrum in how the "peening" is applied, the magnitude of forces used, and how uniformly they are applied to a surface. Historically, the term peening dates back to blacksmithing practices used to create large scale plastic (permanent) deformations of metal implements. In the early boiler codes developed for riveted boilers, plates were joined by rivets, the heads of which were formed by a peening process.

With the advent of welded boilers and pressure vessels, the peening process again found limited application for removing large-scale distortions and residual stresses induced by welding processes. David Waskey, chair of the ASME Section XI – Rules for Inservice Inspection of Nuclear Power Plant Components working group on Welding and Special Repair Processes since May 1996, has explained that the peening restriction in the code case was carried over from the ASME Code, Section III (NB-4422). He has further stated that: *"The Code and subsequent Code Case restrictions on peening were based on the 'crude' peening method used in the old days for dimensional control purposes. This crude (peening) method was implemented by taking a rounded air chisel and hitting the weld pass while it was still very hot. This type of localized heavy cold work was not conducive to surface examinations because even after grinding, indications could have been peened over and embedded. I think this peening technique was a very old method used during early fabrication days. In my 14 years at the Babcock & Wilcox plant I never remember this practice being used. In fact, the only place we have ever used this method of peening in commercial nuclear service work was sealing over through-wall leaks before first layer structural weld overlays on austenitic materials* (as permitted by ASME Section XI, Appendix Q, Article Q-2000, paragraph (b)). *The rotary peening technology we use for surface mitigation is quite mild compared to the single point air chisel peening."*

In follow-up RAI-2 from the NRC letter dated February 23, 2012, the NRC states: "Peening is a process which can crack or otherwise damage welds. It can also mask nondestructive examination methods from identifying defects in a weld. If peening is performed on a weld the potential for creating or masking defects exists." NMPNS agrees with this statement in the context of the type of 'crude' peening methods described above. The controlled peening methods developed and qualified for remediation of the Nine Mile Point Unit 1 (NMP1) control rod drive (CRD) housing penetration repair welds are not in this category of peening methods. Such controlled peening methods have long been practiced and accepted by the aerospace and automotives industries, and are recommended for mitigation of stress corrosion cracking (SCC) by ASME Section III for new designs under Appendix W (see Section below).

Origin of Stress Improvement Peening

Beginning in the late 1940s, the aerospace industry, seeking to mitigate catastrophic fatigue failures in rotating shafts (such as helicopters) and aircraft landing gear, discovered that if a compressive residual surface stress could be imparted to the surface, the resistance to fatigue crack initiation could be significantly delayed or eliminated. It was discovered that uniform application of a controlled peening process through the use of "shot" could create the desired condition. The "shot peening" process, by which shot, propelled by an air "gun," is used to condition the surface, was pioneered by the Metal Improvement Corporation.

Acceptance and usage increased after General Motors (J. O. Almen) developed a standardized means by which the desired amount of residual stress could be measured to control the process. Subsequently, shot peening has found wide application and acceptance in the aerospace industry. As an example of the confidence in the process, the U.S. Federal Aviation Administration allows a 3000 cycle extension of the interval between inspections for jet engine components which have been preventatively shot peened. Application of peening methodologies for imparting residual compressive stresses has subsequently spread to the transportation (crankshafts, torsion bars, brake pins, valve springs) and power generation industries. Non-welded areas routinely peened are the blade fit area and blade rim attachments found on turbine rotors to improve resistance to SCC. Feedwater heater channel-to-tubesheet welds and heat-affected zones (HAZs) subject to thermal fatigue have been successfully mitigated by shot peening (and is accepted by ASME Section VIII for pressure vessels - see below). Adaptation of controlled shot peening methods for reducing susceptibility to SCC in austenitic stainless steels was pioneered by the Japanese starting in the early 1980s and was first applied in a BWR reactor vessel (core shroud) at Chubu Electric Company's Hamaoka Plant in the mid-1990s (see section below for Japanese experience).

ASME Code Section III, Appendix W, Guidance for Stress Improvement by Peening

The ASME Code (2004 Edition), Section III, Appendix W, presents guidance summaries for potential service degradation mechanisms not explicitly covered by ASME Section III design requirements. Although such service degradation is not addressed in the Code, Section III recognizes the need for the Owner to provide requirements to limit material deterioration to acceptable levels for the life of the component. The following excerpt from NCA-1130 of Section III expresses the intent of the Code in this regard.

> *"The rules of this Section provide requirements for new construction and include consideration of mechanical and thermal stresses due to cyclic operation. They do not cover deterioration, which may occur in service as a result of radiation effects, corrosion or erosion. These effects shall be taken into account with a view to realizing the design or the specified life of the components."*

The objective of Appendix W is to provide further guidance regarding service degradation mechanisms, including material selection, treatment and testing; design limitations; and mitigating actions, based on a review of the literature and industry practice are summarized for each damage mechanism. A summary for the SCC mechanism is found in Articles W-2000, "Summaries of Corrosion Damage Mechanisms," W-2100, "Stress Corrosion Cracking," and specifically in Section W-2140, "Stress Control," which states:

> *"Minimizing applied loads and residual stresses (such as induced by welding) reduces one of the major driving forces for IGSCC (Ref. 1). Stresses associated with the corrosion process are often linked to fabrication and installation. Welding (Ref. 1) residual tensile stresses can be major contributors to the driving force for stress corrosion cracking. Cold working, grinding, bending and high heat input welding should be minimized, unless followed by a qualified heat treatment procedure (as for shop-fabricated components).*
>
> *Methods such as shot peening, heat sink welding (HSW), induction heating stress improvement (IHSI), and mechanical stress improvement (Refs. 8, 16, and 17) can be used to place the inside diameter of piping in a compressive residual stress state to resist SCC."*

NMPNS asserts that it is fully following the intent of the ASME Code Section III as described in NCA-1130 and Appendix W through the application of Roto-Peening, a tightly controlled version of shot peening. NMPNS does not believe that this form of stress improvement (i.e., Roto-peening) is a deviation from the intent of the Section III Code.

ASME Code Section VIII Endorsement of Stress Improvement Peening

The ASME Code (2001 Edition through 2010 Edition, and 2011 Addenda), Section VIII, Division 1, "Rules for Construction of Pressure Vessels," is the pressure vessel construction code which applies to non-nuclear pressure vessels (e.g., feedwater heaters). Part UW, "Requirements for Pressure Vessels Fabricated by Welding," states the following in Section UW-39, "Peening:"

> *"(a) Weld metal and heat affected zones may be peened by manual, electric, or pneumatic means when it is deemed necessary or helpful to control distortion, to relieve residual stresses, or to improve the quality of the weld. Peening shall not be used on the initial (root) layer of weld metal nor on the final (face) layer unless the weld is subsequently postweld heat treated. In no case, however, is peening to be performed in lieu of any postweld heat treatment required by these rules.*
> *(b) Controlled shot peening and other similar methods which are intended only to enhance surface properties of the vessel or vessel parts shall be performed after any nondestructive examinations and pressure tests required by these rules."*

Part (a) of ASME Section VIII, Section UW-39 is very similar to the current restriction placed on peening by ASME Section III, NB-4422, and by ASME Code Case N-606-1, Paragraph 1(f).

Unlike Section III and Code Case N-606-1, Section VIII does make a clear distinction between (a) conventional 'crude' peening (heavy mechanical impact of a tool on the weld) and (b) controlled shot peening, prohibiting the former and permitting the latter on the final weld layer. The limitation of UW-39 Part (a) (Peening shall not be used.....on the final (face) layer unless the weld is subsequently post-weld heat treated) cannot apply to UW-39 Part (b) because post-weld heat-treatment after controlled shot peening would reverse the beneficial effect; i.e., the compressive stresses that are intended only to enhance surface properties.

Future Direction for Pressurized Water Reactor (PWR) Dissimilar Weld Primary Water Stress Corrosion Cracking (PWSCC) Mitigation through Stress Improvement by Peening Methods – ASME Code Section XI Examination Interval Extension

In addition to being endorsed in ASME Section III for new designs through Appendix W, the use of controlled peening processes for in-situ PWSCC mitigation to obtain inspection relief for existing dissimilar metal welds used for PWR reactor coolant system components was discussed at the November 2011 ASME Code meeting and was also presented by the Electric Power Research Institute (EPRI) to the NRC Office of Nuclear Regulatory Research (RES) staff at a January 24-26, 2012 Public Meeting on PWR materials reliability and weld repair research. Attendance included 38 representatives from RES, the NRC Office of Nuclear Reactor Regulation (NRR), RES contractors, and the nuclear power industry including EPRI, AREVA, Westinghouse, General Electric, Structural Integrity Associates, Exelon, Entergy, Dominion Engineering Incorporated, Hill Engineering, Wolf Creek Nuclear Operating Company, First Energy Nuclear Operating Company, Oak Ridge National Laboratory, and Southern Nuclear Company.

The goal of the current industry efforts is to add controlled peening methods to the already accepted PWSCC mitigation methods described in ASME Code Cases N-770 and N-729 (i.e., mechanical stress improvement process (MSIP), weld overlay (WOL), and weld inlay). To this end, the PWR Material Reliability Program, led by EPRI, has an active industry-funded 2012 program to develop the technical basis and criteria for ASME to accept controlled peening methods to enable their inclusion in Code Cases N-770 and N-729.

Japanese Experience – BWR Core Shroud Mitigation through Stress Improvement by Peening Methods

Chubu Electric Power Company presented their work related to the use of shot peening as a SCC mitigation technique in the BWR Vessel and Internals Project document BWRVIP-23, "Proceedings: BWRVIP Symposium, Buena Vista, Florida, November 6-7, 1996," (EPRI Report TR-107280, December 1996). Their testing demonstrated that shot peening is an effective method to induce compressive stresses in the surface layer of core shroud welds to prevent intergranular stress corrosion cracking (IGSCC) initiation. The shot peening process was effectively implemented at Hamaoka Units 1 & 2 (reference: BWRVIP-65). Chuba Electric later improved the core shot peening process by developing a laser peening process. This process was easier to implement in-situ by eliminating the need for shot grain. Laser peening was also applied to Hamaoka Unit 1 as discussed in BWRVIP-65 and BWRVIP-101. More recent operating experience indicates that laser peening has been applied to multiple Japanese plants between 1999 and 2007. In-vessel components such as core shroud horizontal/vertical welds, CRD stub tubes, and a reactor vessel nozzle, were laser peened.

Technical Basis for NMP1 CRD Housing Penetration Repair Weld Roto-Peening

It is NMPNS' position that the proposed CRD housing penetration weld repair under Code Case N-606-1 will be enhanced by application of a controlled surface peening process. Specifically, the susceptibility to SCC will be significantly reduced, particularly at the heat affected zone of the 304 stainless steel (SS) remnant housing. The technical basis to support this claim specifically for the proposed NMP1 CRD housing penetration repair configuration has been jointly developed by NMPNS and AREVA.

The Roto-peening captive shot technology was developed by 3M Corporation for small and/or hard-to-reach surfaces. For the CRD housing penetration weld repair, controlled application of loose shot inside the cylindrical tube would be problematic and potentially ineffective. With Roto-peening, the shot is integrated, or captured, in a flap. The spinning (hence Roto) flap is held near the surface so that the captive shot strikes the metal surface consistently with each revolution. Two flexible polymeric flaps are bonded together to encapsulate uniformly sized and spaced tungsten carbide shot within an adhesive matrix. This provides for a cleaner process and more precise control than can be achieved with loose shot peening.

The essential variables of the Roto-peening process were developed after first determining the desired target "intensity" to be applied to the surface of interest. This intensity is proportional to the magnitude of the residual compressive stress at the surface. [[

]]

Table 1 – Roto-peening Process Development Sample Data

[[

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The effectiveness of the Roto-peening process to prevent SCC at a weld HAZ was demonstrated on many samples by the industry accepted ASTM G36 method: "Standard Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution." [[

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[[

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Figure 1 – Upper Half of Weld Bead on Plate in Process of Being Roto-peened

[[

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Figure 2 – Result of Liquid Penetrant Exam after Magnesium Chloride Exposure (24 hours @ ~ 315°F)

The last set of samples based on a full size mock-up served to address the issue of thermal stability of the Roto-peened surface to make sure that the beneficial residual stresses were thermally stable such that they did not diminish or become tensile when subjected to high temperature [[ ]]. To accomplish this, a total of [[ ]] samples were prepared, with half of them subjected to the Roto-peening stress improvement. Half of the samples also received thermal treatment at [[ ]]. In addition, [[ ]] samples were checked by X-Ray diffraction (an accepted industry method for measuring the magnitude and depth profile of the residual stresses), while the remaining [[ ]] were subjected to the boiling magnesium chloride SCC susceptibility test. The test matrix used is shown in Table 2 below along with the magnesium chloride cracking results. As before, [[ ]]

Representative samples are shown in Figures 3 and 4.

The [[ ]] samples that underwent magnesium chloride testing were tested utilizing the liquid penetrant inspection method to detect any surface cracks that may not have been visible during the process of taking photo macrographs. Penetrant dye (PT) testing results are displayed in Table 2 below. Results indicate that [[ ]]

Table 2 – Magnesium Chloride and Penetrant Dye Testing Results

[[

]]

[[

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Figure 3 – Sample RP-M-01 - Roto–Peened (View of Weld, HAZ and Base Metal, No Thermal Cycle) X-Ray Diffraction Testing Results

[[

]]

Figure 4 – Sample RP-M-02 - Not Roto–Peened (View of HAZ and Base Metal, No Thermal Cycle) X-Ray Diffraction Testing Results

The final test performed was to characterize the stress profile imparted by the Roto-peening process through the use of non-destructive X-Ray diffraction methods. The sample test matrix is shown in Table 3 below.

Table 3 – X-Ray Diffraction Testing Results

[[

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[[

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[[

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Figure 5 – Axial and Tangential Residual Stress Depth Profile for As-welded (not Roto-Peened) Sample ARP-X-02. [[ ]]

[[

]]

Figure 6 – Axial and Tangential Residual Stress Depth Profile for Roto-Peened Sample ARP-X-01. [[ ]]

[[

]]

Figure 7 – Axial and Tangential Residual Stress Depth Profile for As-welded (not Roto-Peened) Sample ARP-TX-02 after a Thermal Cycle. [[ ]]

[[

]]

Figure 8 – Axial and Tangential Residual Stress Depth Profile for Roto-Peened Sample ARP-TX-01 after a Thermal Cycle. [[ ]]

The test results illustrated above show that, in general, [[

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Conclusions

Based on the results of the X-Ray diffraction testing and the extensive magnesium chloride testing, Roto-peening as applied by the controlled process described has proven to be an effective method of inducing consistent surface compressive residual stresses in a weld repaired component. [[

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Stress improvement methods intended to improve resistance to SCC applied to a final weld layer, such as by Roto-peening, have been endorsed by ASME Section III, Appendix W, and ASME Section VIII Division 1. These stress improvement methods have been successfully applied to several existing and new construction BWR components in Japan. The EPRI Materials Reliability Program (MRP) is currently pursuing development of stress improvement approaches for the domestic PWR fleet for the mitigation of PWSCC, including development of an ASME Code Case (see MRP-267 and MRP-335 references below).

References

1) Nine Mile Point 1 – CRDH Stub Tube Repair – Roto Peening Test Plan, AREVA Doc. No. 51-9139652-002 (3/8/2011)
2) Roto Peening Test Plan and Results, AREVA Doc. No. 51-9127883-000 (3/8/2011)
3) Nine Mile Point 1 – CRDH Stub Tube Repair – Roto Peening Test Results, AREVA Doc. No. 51-9142920-004 (9/7/2011)
4) AREVA Document 38-9150509-000 – Residual Stresses Analysis of 8 Pipe Coupons
5) Military Specification; Wheels, Peening, Rotary Flap, MIL-W-81840 (AS)
6) Military Specification; Rotary Flap Peening of Metal Parts, MIL-R-81841 (AS)

7) 3M Surface Conditioning Products, Application Notes for 3M Roto Peen Flap Assemblies TC330
8) Control Of Stress Corrosion Cracking By Shot Peening, M. Takemoto, T. Shinohara, and M. Shirai, proceedings of the International Conference on Shot Peening (ICSP-1), Paris France, 1981, pp 521-527
9) Standard Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution, ASTM G36
10) Technical Basis for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement, EPRI MRP-267 (DRAFT)
11) Topical Report on Surface Stress Improvement for Mitigation of Primary Water Stress Corrosion Cracking, EPRI MRP-335 (DRAFT)

ATTACHMENT 4

AFFIDAVIT FROM AREVA NP INC. JUSTIFYING WITHHOLDING PROPRIETARY INFORMATION

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by

AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in the White Paper entitled "White Paper Regarding Peening," submitted April 2012 and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of

proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 6th day of April, 2012.

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2015
Reg. #110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2015