ENCLOSURES 7 AND 8 CONTAIN PROPRIETARY INFORMATION.
WITHHOLD FROM PUBLIC DISCLOSURE UNDER 10 CFR 2.390.

Xcel Energy®

Monticello Nuclear Generating Plant
2807 W County Road 75
Monticello, MN 55362

July 2, 2013

L-MT-13-040
10 CFR 50.55(a)

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Monticello Nuclear Generating Plant
Docket No. 50-263
Renewed Facility Operating License No. DPR-22

<u>Supplemental Information Regarding Cycle 25 Inservice Inspection Summary Report – Core Shroud Support Flaw Evaluation</u>

References: 1) NSPM to NRC, "Cycle 25 Inservice Inspection Summary Report," (L-MT-11-046) dated August 23, 2011 (ADAMS Accession No. ML112351222).

On August 23, 2011, in accordance with 10 CFR 50.55(a), the Northern States Power Company – Minnesota (NSPM), doing business as Xcel Energy, Inc., submitted the Cycle 25 Inservice Inspection (ISI) Summary Report (Owner's Activity Report, Form OAR-1) for the Monticello Nuclear Generating Plant (MNGP) (Reference 1).

The Owner's Activity Report (OAR) was prepared in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI Code Case N-532-4, "Repair/Replacement Activity Documentation Requirements and Inservice Summary Report Preparation and Submission, Section XI, Division 1."

The OAR summarized the results of the inservice examinations performed during Cycle 25 (including the 2011 Refueling Outage). Table 1 of the OAR provided a listing of relevant indications that required further engineering evaluation to support continued service. Engineering evaluation of relevant indications identified in the core shroud support welds were completed, and determined to be acceptable-as-is.

Pursuant to the requirements of ASME Section XI, paragraph IWB-3144(b), Enclosures 1 through 4 provide the flaw evaluations performed for the core shroud support welds to support continued service. The evaluations had not been included with the Reference 1

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submittal. Enclosure 1 provides an overall summary of the examinations and inspections performed for the core shroud support welds. Enclosures 2 through 4, and Enclosures 7 and 8 provide the detailed engineering evaluations prepared by Structural Integrity Associates, Inc (SIA) which includes information provided by the Electric Power Research Institute (EPRI).

Enclosures 3 and 4 are non-proprietary versions of the engineering evaluations prepared by SIA. The proprietary versions of the engineering evaluations are presented in Enclosures 7 and 8. NSPM requests to withhold Enclosures 7 and 8 from public disclosure in accordance with 10 CFR 2.390(b)(1). The affidavit from SIA detailing the reason for the request to withhold the proprietary information contained in Enclosure 7 is provided in Enclosure 5. The affidavit from EPRI detailing the reason for the request to withhold the proprietary information contained in Enclosure 8 is provided in Enclosure 6.

Should you have questions regarding this letter, please contact Mr. Richard Loeffler at (763) 295-1247.

Summary of Commitments

This letter proposes no new commitments and does not revise any existing commitments.

Mark A. Schimmel
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Northern States Power Company – Minnesota

Enclosures (8)

cc: Administrator, Region III, USNRC
Resident Inspector, Monticello, USNRC
Project Manager, Monticello, USNRC
BWRVIP Project Manager, USNRC

ENCLOSURE 1

MONTICELLO NUCLEAR GENERATING PLANT

SUPPLEMENTAL INFORMATION REGARDING CYCLE 25 INSERVICE INSPECTION SUMMARY REPORT – CORE SHROUD SUPPORT FLAW EVALUATION

EC-18068
SUMMARY OF 2011 SHROUD SUPPORT INSPECTION AND EVALUATION ACTIVITIES

(Refer to EC-18068 for Approvals)

(15 pages follow)

Executive Summary

On April 2, 2011 indications were discovered on the bottom side of the shroud support plate. The indications were identified while performing inspections of shroud support leg welds in the lower plenum region. The extent of the linear indications were extensive and extended beyond the field of view from the camera. The indications were in an alloy 182 welds on both the RPV side of the shroud support plate and the shroud side of the shroud support plate. Alloy 182 welds are known for acquiring a heavy layer of scale that can affect the inspection of the surface condition. Attempts were made to clean a local area where the indications were first identified. Due to access limitations, new tooling was constructed to remove the surface crud and scale that was present. The cleaning effort was not sufficient to prepare the surface to a condition where the surface could be ruled free of indications. Additional limited exams were performed using an ultrasonic inspection technique from the vessel outside diameter. The scope of UT inspection was limited to scanning the base metal in the axial direction. An axial scan would best suited to identify circumferential cracking (which was the predominant nature of the indication). The inspection was completed with no reportable indications. Following completion of UT inspection, the extent of condition inspection was completed through jet pumps 1 through 19 with similar results as seen in Jet pump 14. MNGP accepted these as indications and performed stress analysis to demonstrate that the shroud support structure would still meet its design requirements. An additional assessment was performed to demonstrate the low alloy reactor base metal would not be affected flaws growing from the alloy 182 weld metal. Therefore, the MNGP RPV and shroud support structure meets the design requirements and is ready to exit the spring 2011 RFO.

Purpose

The purpose of this evaluation is provide background and rational behind inspection activities. Additionally this evaluation will summarize the results of the two engineering analysis documented in EC18051 [13] and EC 18067 [14].

Applicable Internals Design Configuration

The reactor internals are designed mechanically to provide an adequate distribution of coolant flow within the reactor and maintain structural integrity during normal operations, seismic disturbances, and design basis accident conditions.

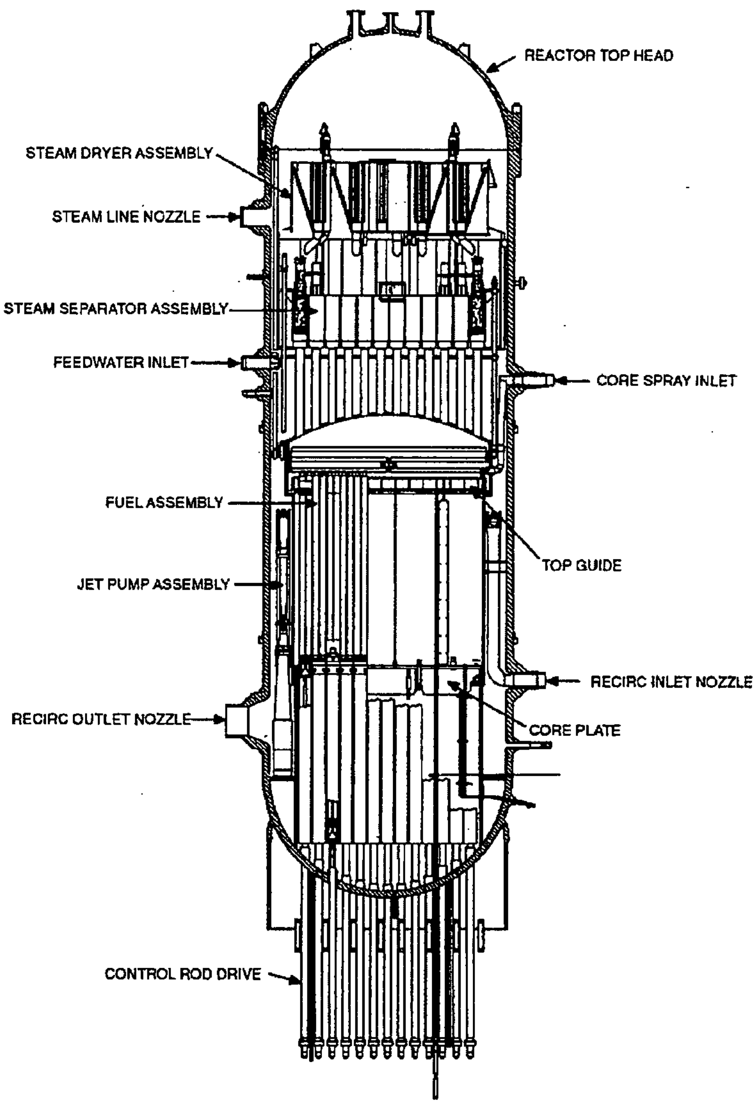

Figure 1: Vessel Internals Configuration

Shroud

The shroud is a stainless steel cylinder which surrounds the reactor core and provides a barrier to separate the upward flow of coolant through the reactor core from the downward recirculation flow. Bolted on top of the shroud is the steam separator assembly which forms the top of the core discharge plenum. This provides a mixing chamber before the steam-water mixture enters the steam separator. Refer to figure 1 for the reactor vessel cutaway isometric for illustration of parts arrangement.

The bottom of the shroud is welded to a rim on the baffle plate. The baffle plate outer diameter is welded to the reactor vessel and the inner diameter is supported by columns extending to the bottom head.

Baffle Plate (Synonymous with Shroud Support Plate)

The recirculation outlet and inlet plenum are separated by the baffle plate joining the bottom of the shroud to the vessel wall. The jet pump diffusers extend through holes in the baffle plate, and are welded to the baffle plate. A special adapter piece is used to make the transition from the pump to the plate. The baffle plate and inner rim are of Inconel for welding to the ferritic base metal of the reactor vessel. The bottom of the shroud is welded on top of the rim, which provides for the differential expansion between the ferritic, Inconel, and stainless steel components. Inconel legs welded at intervals around the baffle plate support it from the vessel bottom head.

Baffle Plate Support (Synonymous with Shroud Legs)

The baffle plate supports carry all the vertical weight of the shroud steam separator and dryer assembly, top and bottom core grids, peripheral fuel assemblies, and core plugs not carried on guide tubes, and jet pump components carried on the shroud. In addition, the supports must withstand the differential pressures of normal operations and blow down accidents (either upward or downward), and for the vertical and horizontal thrusts of the seismic design.

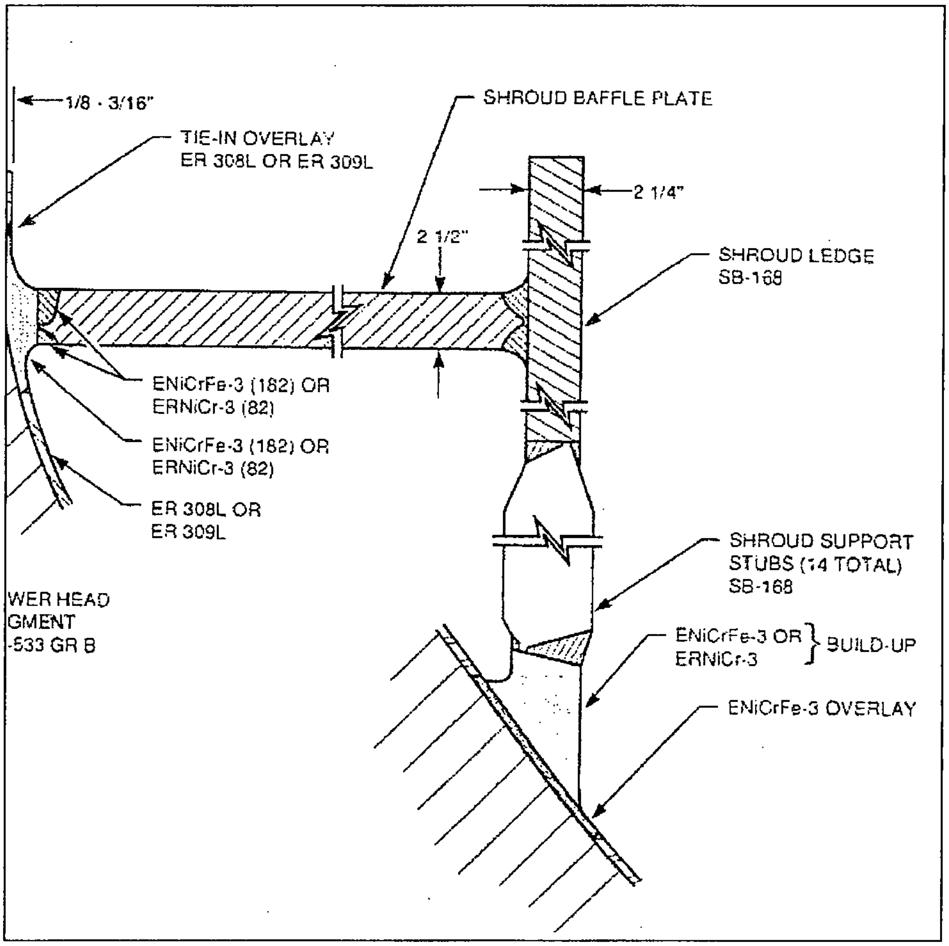

Figure 2: H8, H9 and Shroud Leg Configuration

History of Inspection

Monticello routinely inspects the shroud support legs. This activity began in the 2000 RFO following the first identified instance of shroud leg cracking. Cracking was first identified on the 210 degree shroud support leg (See CAP 650746). The remaining shroud legs were inspected during the 2000 RFO as an extent of condition. It was determined that the remaining legs were acceptable for use with no indications. These inspections and results are documented in reference 4 provided by the vendor supporting the 2000 inspection. Structural Integrity Associates performed an evaluation which assessed the load carrying capability of the core support structure and found it acceptable.

Monticello continued to carry the 210 degree shroud leg indication as an active indication. In accordance with ASME Section XI Table 2500-1 Item 13.40. ASME Section XI (1995 Edition with 1996 Addenda) (Ref 2), the following in-service inspection requirements for welded core support structure are as follows:

- Core support structure is categorized as Item No. B13.40 (Category B-N-2) per Table 2500-1. The acceptance standard for inspections of item B13.40 is paragraph IWB-3520.2.
- The requirements in IWB-3520.2 described the relevant conditions and require meeting IWB-3122 prior to service or IWB-3142 prior to continued service.
- Paragraph IWB-3122.2 requires compliance to IWB-3200 where subparagraph (b) requires extent of condition review.
- Paragraph IWB-3142.1(b) states that continued service is not allowed unless the requirements of IWB-3142.2, IWB-3142.3 or IWB-3142.4 are met.
- IWB-3142.4 states the component can be accepted by analysis and shall be subsequently examined in accordance with IWB-2420(b) and (c). Note: IWB-3144(b) states evaluation analyses of examination results as required by IWB-3142.4 shall be submitted to the regulatory authority having jurisdiction at the plant site.
- IWB-2420(b) indicates the area containing relevant conditions shall be reexamined during the next three inspection periods defined by the program.

Subsequently, Monticello was performing the required repeat inspection of the 210 degree leg in 2009 (as required by IWB-2420(b)) when additional indications were noted on other shroud support legs[1]. The discovery of these indications in 2009 resulted in the code required inspection cycle repeating for the new indications. The inspections in 2009 were performed with a fixed focus length color camera which limited viewing of the areas of the H8 and H9 welds. Regions in areas such as the shroud support plate would not have clear camera focus for the focal length for a camera targeting a shroud leg exam. This would have resulted from an equipment induced "tunnel vision" and well as inspectors intently focusing on shroud support H10 leg weld.

2011 Activities

Visual Exams

In 2011, a vendor (different from the vendor used in 2000 and 2009) was utilized to perform in vessel visual inspections (IVVI). The scope of the exam included the shroud legs with previous indications indentified in 2009. This examination was required to meet paragraph IWB-2420(b) as the 2011 outage is the only outage in the third period of the 4th ISI interval. The vendor was requested to bring cameras that would provide better resolution for the shroud leg exam. The goal of better resolution cameras was to resolve the shroud leg indications as non-relevant due to the improved resolution.

[1] During the extent of condition inspection in 2000 all additional legs were inspected and documented in the 2000 inspection report. The indications observed in the 2000 were similar to those observed in 2009. The 2000 examination dispositioned as acceptable (Ref 4 Section 3 Tab 4). Review of the year 2000 video indicates that many of the same indications were present but dispositioned as non-relevant. In accordance with PEI-02.05.05, as the 2009 indications could not be resolved, the indications were identified as relevant indications. See PEI-02.05.05 Section 13.1.1.B.

While performing inspection of the H10 weld, the bottom side of the H8 and H9 welds could be seen in the background. This would have been dependant upon camera positioning. With the enhanced camera resolution and the ability to change focal length, indications on the bottom side of the shroud support plate were visible at the H8 and H9 welds. Upon further investigation from jet pump diffuser area, it could be seen that crack like indications were present on the surface of the weld. Below are sample images.

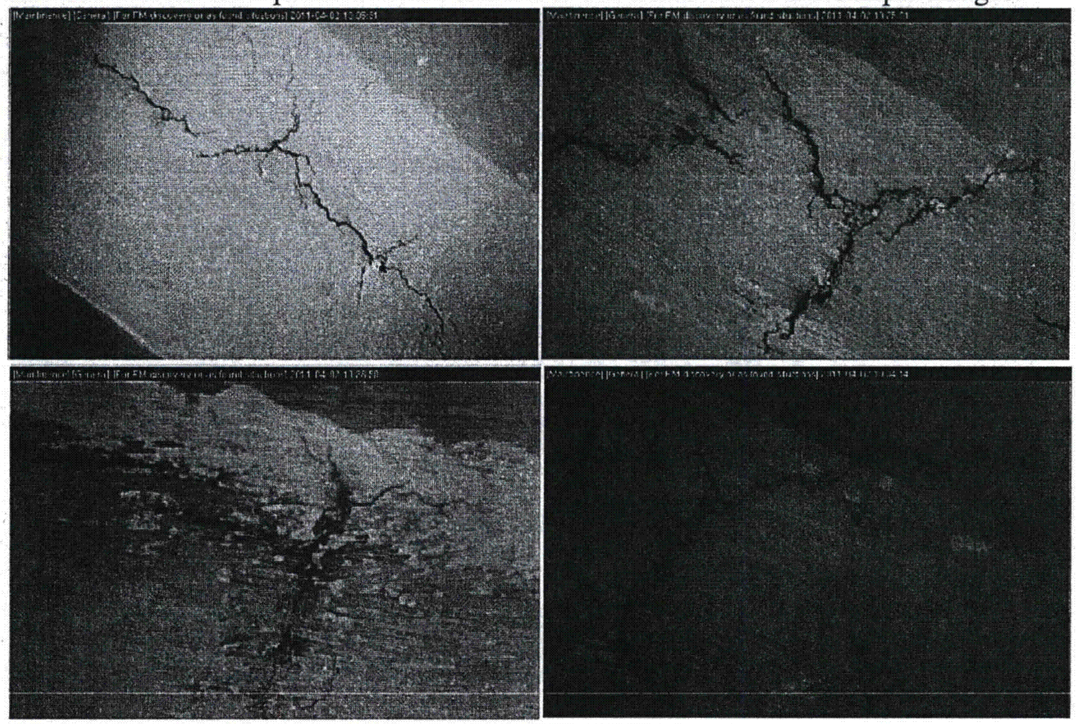

Figure 3: As Found H9 Images

Surface Conditions

It is well known in the industry that the scale build up on nickel based welds is aggressive and difficult to remove. For example, MNGP did a first time inspection of the AD-1 weld on the jet pumps in 2007. AD-1 is nickel based weld that is machined flush. The presence of scale completely masked its existence. The image is from the data collection video from 2007.

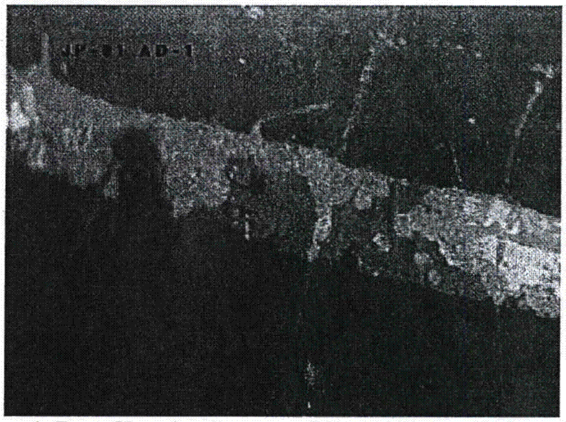

Figure 4: Post Cleaning Images of JP-1 AD-1 weld from 2007

It is plainly visible that the cleaning had an effect at AD-1. Areas adjacent to the weld remain coated with a red oxide layer while a layer of scale is removed on the weld revealing the yellowish hue of the nickel based alloy. A portion of the weld still has areas where the scale intrudes into the weld metal (left half of image above). It can also be seen where the tip of the cleaning tool travelled vertically through the weld area into the base metal. The base metal has a different color than the weld. Lastly, it can be observed that the cleaned area edges are bounded with an irregular interface between the cleaned and uncleaned surfaces. This would tend to indicate scale existed on the surface and removed in brittle flakes.

With reference to the as found images of the H9 weld(figure 3), the images present a lack of contrast. Much greater contrast would be expected between the weld metal and the base metal weld with the scale removed from the base metal. The similarity in contrast between the weld metal and base metal would tend to indicate a heavy deposit build up.

Due to access limitations, a cleaning nozzle similar to the nozzle used on AD-1 was unable to be deployed. A small wand fabricated in stock ¼" stainless steel Swagelock fittings and stainless steel tubing was used for hydrolazing the bottom side of the H9 weld. The ends of the tubes were open and did not contain "engineered fittings" to enhance the jet forces. The cleaning action from this tool was closer to a high intensity flush rather than a water pick. The image below shows the results of those cleaning actions after 30 minutes in a very isolated area.

MNGP RFO 25 H9 at approximately 215° Hydrolazed

Hydrolazed area. Applied 5400 psi hydrolazer for 30 minutes.

Figure 5: Post Hydrolazing Image from H9

While it can be seen there was some effect, the deepening in color would indicate the removal a crud layer. Therefore, the only effect on the surface was the removal of surface deposits.

Another tool was fabricated to attempt to scrape the surface layer of scale from the surface. The tool consisted of a pipe fittings with a nozzle providing thrust to a stainless steel spire. This tool was powered by the hydrolazer pump. The following are images of the post scraping weld area.

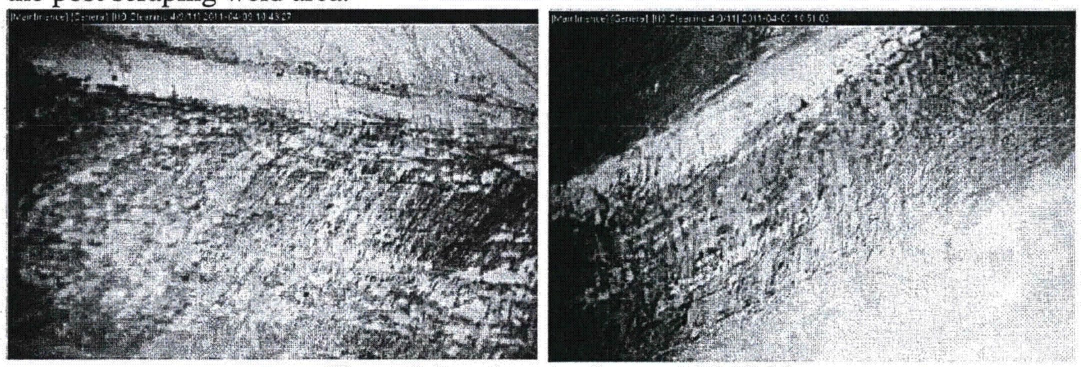

Figure 6: Post Scraping Image of H9 Weld

While is clear there is an effect on the surface (as was evidenced by the bursts of debris from the surface), the surface condition is not ideal for inspection. The surface is not in a condition that meets the requirements for a surface exam per PEI.02.05.05 (Excerpts below).

"10.4.1 Surfaces to be inspected ***SHALL*** be sufficiently free from deleterious materials such as crud deposits and other conditions that would prevent detection of the smallest expected indication.

10.4.2 Cleaning methods ***SHALL NOT*** smear any surface sediment, which could mask or hinder detection of indications. Cleaning methods ***SHALL*** also not produce a polished surface finish that could cause excessive glare and prevent detecting indications."

While one could surmise that portions of the type of indication seen figure 3 are not present in post scraping images. What cannot be said is that the surface is free of indication. Additionally, if the indications present in figure 3 were being 1) driven by a real surface condition or 2) created an local crevice to act as an ion trap, the surface condition would need further improvement to state the initial indications are no longer present.

Inspections of H8 and H9 Welds From Above The Shroud Support Plate

Inspections of the H8 and H9 welds (above the shroud support plant) were scheduled for the 2011 outage and completed. The inspection report indicates no indications on the top side of H8 and H9. The inspection results have been reviewed by NSPM personnel with extensive experience visual inspection experience. The inspection was completed to EVT-1 standards and the coverage was approximately 17% of the entire vessel circumference length. The BWRVIP-38 requires coverage is 10%. Inspection area was limited to the area below the N1A and N1B nozzles.

Ultrasonic Exams

As a means of better understanding the material condition of the H9 weld, UT options were explored. However, MNGP has limited access to the RPV OD adjacent to the H9 welds. Below is a schematic of the access made available by Removable Insulation Panels (RIPs) at the N1B nozzle. Proximity of the vessel welds to the H9 weld was taken from reference 5. (Image rotated 90 degrees CCW from in field configuration).

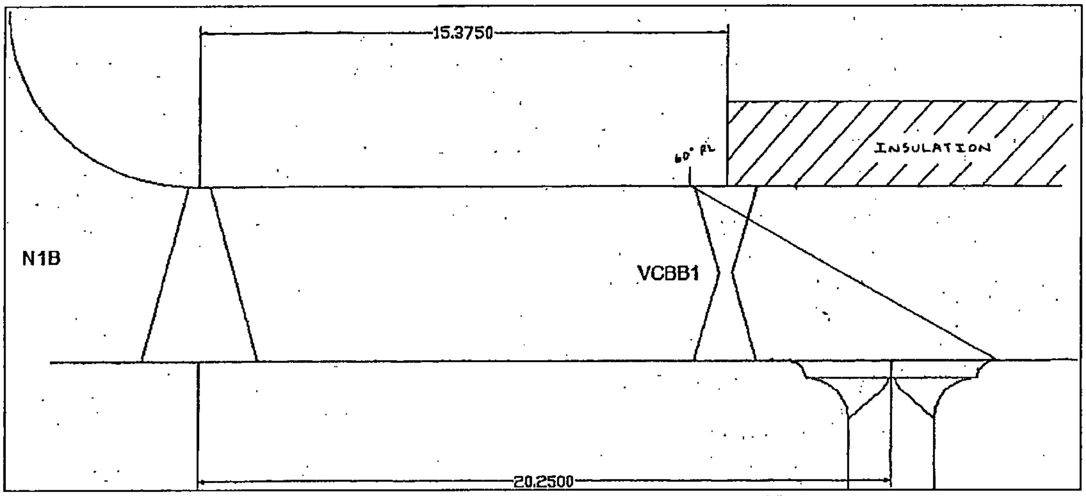

Figure 7: Accessibility of H9 from N1B Nozzle Window

As-built dimensions were taken for UT inspection accessibility. The gap between in the insulation package and the vessel was measured and is minimal. Relative to the space required by a UT package, there is no gap and therefore vessel OD access adjacent to the H9 is not accessible. Additionally, images taken during the access study show restraining bands around the insulation panels. The affect of removing the banding from the insulation panels were unknown with several courses of insulation remaining stacked on top of the row in question. Due to the risk of collapse, the insulation banding was not removed. There is no ability to force the insulation package from the vessel wall to gain the 3" clearance needed for demonstrated H9 inspection tool. Insulation was removed from N1B window to allow for 72" of lateral access to the reactor vessel surface above the H9 weld and perform the required ISI inspections.

The decision was made not perform the same activity at the N1A nozzle window. There are many interferences at the N1A window. Initial dose estimates approached 10 REM to gain access to the metal adjacent to the H9 weld through the N1A window. Subsequently, this activity was not pursued.

Visual inspections were conducted from Jet Pump 10 and Jet Pump 11 of the bottom of H9 in the area below the N1B nozzle. The visual inspections indicated that circumferential branching observed 12" counter clockwise from jet pump 11(outer edge) 180 degree azimuth of the reactor vessel. This would indicate the indication extends from beyond 210 degrees vessel azimuth to 192 degree azimuth (Calculated below). This inspection was performed just prior to the UT inspection and the inspection results were shared with the UT inspector.

$$\theta_{Start} = \theta_{N2F} - \left(\left(D_{JP11} + \frac{Dia_{JetPump}}{2} \right) + L_{Ind} \right) \frac{360 Degrees}{\pi (ID_{vessel})}$$

Where:

$\theta_{Start} = Azimuth\_start\_of\_Indication\_(Degrees)$

$\theta_{N2F} = Center\_Line\_Azimuth\_of\_N2F\_Nozzle(Degrees) = 210 Degrees[12]$

$D_{JP11} = Distance\_from\_N2F\_to\_JP11\_Centerline(Inches) = 12.5625''[12]$

$Dia_{JetPump} = Jet\_Pump\_Nozzle\_Opening\_Diameter(Inches) = 14''[12]$

$L_{Ind} = Lenght\_of\_Indication\_from\_JP11\_edge\_towards\_180 = 12''$

$ID_{vessel} = Vessel\_ID(Inches) = 206''[10]$

$$\theta_{Start} = 210° - \left(\left(12.5625'' + \frac{14''}{2} \right) + 12'' \right) \frac{360°}{\pi (206'')} = 192°$$

The anticipated overlap in coverage from the report indication to the planned UT coverage was validated prior to performing the UT inspection.

$$\theta_{coverage} = \theta_{N1B} \pm \left(\tfrac{L_{Scan}}{2} \right) \frac{360°}{\pi (ID_{vessel} + 2t)}$$

Where

$\theta_{coverage} = Scan\_Coverage$

$\theta_{N1B} = N1B\_Nozzle\_Azimuth = 180°[11]$

$L_{Scan} = Length\_of\_Scan = 72\_inches$

$ID_{vessel} = Vessel\_ID(Inches) = 206''[10]$

$t = Vessel\_Wall\_Thickness(Inches) = 5.0625''[10]$

$$\theta_{coverage} = 180° \pm \left(\tfrac{72''}{2} \right) \frac{360°}{\pi (206'' + 2(5.0625''))} = 161°, 199°$$

The 7 degrees of overlap would result in approximately 12 inches of weld scan where ID indications would have been detectable is growing into the RPV base metal.

The inspection of the vessel base metal adjacent to the H9 weld was performed. This inspection was performed from the N1B nozzle window. Insulation removed from that window allowed for 72" of lateral access to the reactor vessel surface for an axial scan. As shown in figure 7 access was not available to scan the reactor vessel circumferentially directly on the outside wall of the RPV adjacent to the H9 weld. The inspection was performed utilizing procedure FP-PE-NDE-406 with a PDI qualified examiner. FP-PE-

NDE-406 is PDI procedure that meets the requirements of ASME Section XI, Supplement 8. This procedure is only qualified for vessel base metal and does not provide insight into the H9 weld itself.

The exam was completed with no indications. This specifically means that the UT exam did not identify any indications circumferentially at the H9 weld pad to reactor vessel interface in the low alloy RPV.

Resulting Analysis

Three analysis were completed with the conservative assumptions regarding the nature of the indications. EC 18051 and EC18067 contains bounding assumptions that the indication is truly a crack and that the indication is 360 degrees around the circumference. It can be said that the indications do not extend 360 degrees but the assumption bounds the possible condition. The assumptions of EC18095 will be discussed below.

Core Shroud Support Analysis (EC 18051)

Based on the results of this conservative evaluation, up to 40% of each support leg H10 weld may be flawed (with one leg totally flawed) and still meet the required safety factors of BWRVIP-38. The current indications at H10 are relatively small and essentially not propagating. Even if crack growth is postulated (@$5x10^{-6}$ in/hr), the required safety factors would be met for several operating cycles.

The required safety factor was reached when 40% of the leg width was assumed cracked through-wall along with one leg cracked 100%. These results are considered to be extremely conservative because no structural support from welds H8 and H9 was considered. Therefore, if some structural support from welds H8 and H9 is considered, it is expected that significantly larger margins would be obtained. Assuming no credit for the H8 and H9 welds is equivalent to assuming a through-wall flaw at H8 and H9 welds.

Crack Propagation into the RPV Vessel (EC 18067)

EC 18067 present results that suggest the following conclusions relative the possibility of cracks in Alloy 182 propagating from the Alloy 182 in to the low alloy steel pressure vessel:

1. Significant crack growth in low alloy steel is extremely difficult to obtain in the BWR environment since it requires dynamic loading during plant startup or relatively low frequency cyclic loading due, for instance, to thermal stratification in piping or inadequate mixing of hot and "cold" coolant streams.
2. The lower plenum environment at Monticello, i.e., HWC-M, mitigates crack growth in all BWR structural materials such as austenitic stainless steel, nickel-base alloys (e.g., Alloy 182) and ferritic materials such as RPV low alloy steel.

3. Minimal crack propagation, if any, would be expected in the low alloy steel even if the presumed crack could change direction under expected loading conditions present and propagate toward the vessel.
4. Volumetric inspection of the vessel adjacent to the attachment weld (72" circumference) confirmed that no indications exist in the vessel at the examined locations.

EVALUATION OF SHEAR CAPACITY OF MONTICELLO SHROUD WELDS H8 AND H9 (EC 18095)

EC18095 evaluates the differential pressure loading across the baffle plate. The analysis also considers the USAR chapter 12 required seismic loading. The analysis postulates two scenarios: 1) the cracking is fully circumferential and is 75% through wall; and 2) based upon visual inspection of the top side H8 and H9 being indication free, 66% through wall cracking in inspected regions and 100% through wall cracking in non-inspected regions. The justification for these through-wall cracking lengths are presented in EC18095. When cracking was assumed through-wall, crack growth rates were applied to define the inspection interval. This analysis resulted in significant margin as documented EC18095.

Therefore, it is concluded that the visually observed crack like indications do not pose a concern for the RPV.

Conclusions

Indications in the H8 and H9 welds were identified during the RFO in 2011. The indications are only present on the bottom side of H8 and H9. The top side of H8 and H9 was inspected in the 2011 outage using EVT-1 techniques as required by BWRVIP-38 and VT-3 techniques as required by the ISI program. UT inspections were performed using a PDI demonstrated technique from the N1B window. There were no relevant indications detected at the interface between the low alloy steel and the vessel attachment pad. The inspection would have detected circumferential indications that were predominant in the visual indications observed.

Analysis conservatively bounds the as found condition of the shroud support legs and the H8 and H9 welds. In the shroud support analysis (EC18051), no credit was given to the shroud support plate as a load bearing member and the results were acceptable. Letter analysis (EC 18067) concludes that it is unreasonable to presume that a crack in the H9 weld could grow into the vessel steel considering Monticello's water chemistry, the required change in direction, and a volumetric inspection. Analysis (EC18095) conservatively concludes that the baffle plate will support the differential pressure and seismic loading.

The results of the evaluations to assess the material condition conclude there is no safety issue with the Monticello RPV.

References

1. CAP 650746
2. ASME Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", 1995 Edition with 1996 Addenda.
3. PEI-02.05.05 Rev 5, "Visual Examination of Monticello Reactor Vessel Inspection"
4. "MNGP RF-19 In-Vessel Visual Inspection Final Report" January 2000 Rev 0
5. NX-9310-27 Rev 6, "Shroud Support"
6. BWRVIP-38 "BWRVIP Shroud Support Inspection and Flaw Evaluation Guidelines, September 1997
7. USAR Section 3.6, Rev 25.
8. USAR Section 03.Figures, Rev 26.
9. FP-PE-NDE-406 Rev 1, "Ultrasonic Examination of Reactor Pressure Vessel Welds"
10. Ops Manual B.01.01-02, Rev 2
11. NX-8290-13, Rev 8
12. NX-9310-28, Rev 5 , "Plan for Shroud Support"
13. EC 18051, Rev 0, "EVALUATION OF THE MONTICELLO SHROUD SUPPORT LEG INDICATIONS CONSIDERING INDICATIONS AT WELDS H8 AND H9"
14. EC 18067, Rev 0, "EVALUATION OF CRACK GROWTH INTO THE LOW ALLOY STEEL OF THE REACTOR VESSEL"
15. EC 18095, Rev 0, "EVALUATION OF SHEAR CAPACITY OF MONTICELLO SHROUD WELDS H8 AND H9"

ENCLOSURE 2

MONTICELLO NUCLEAR GENERATING PLANT

SUPPLEMENTAL INFORMATION REGARDING CYCLE 25 INSERVICE INSPECTION SUMMARY REPORT – CORE SHROUD SUPPORT FLAW EVALUATION

EC-18067
STRUCTURAL INTEGRITY OF THE MONTICELLO REACTOR PRESSURE VESSEL

(12 pages follow)

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April 20, 2011
Report No. 1100560.401.R1
Quality Program: ☒ Nuclear ☐ Commercial

Mr. David Potter
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414 Nicollet Mall
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Subject: Structural Integrity of the Monticello Reactor Pressure Vessel

During the spring 2011 inspections of the reactor internals at the Monticello BWR, Xcel Energy visually discovered indications at the H8 (shroud support-to-shroud) weld and the H9 (shroud support-to-vessel) weld as shown in Figures 1 and 2. Previously, in spring 2009, indications had been observed in 11 of the 14 shroud support legs. Monticello is a BWR-3 and fabricated by CB&I. For this vessel, the H8 and H9 welds are full penetration double V welds. Figure 2 shows a schematic of the configuration for Monticello [11, Figure 5-59]. The indications observed were located on the bottom side of the shroud support plate thus exposing them to the water environment of the lower plenum.

Indications were observed in one or both ends of the H10 welds at the top end of the support legs, Figure 3 [1]. The indication shown in Figure 3 runs across the Alloy 182 fillet weld. However, it is very important to note that these flaws exist in the fillet welds that were installed to reduce the stress between the H10 weld and support cylinder. While full characterization of the indications in the H9, Figure 4, (and H8) weld is not currently available, a recent stress evaluation took no credit for integrity of either of these welds to demonstrate structural acceptability of the shroud [2].

Because of the proximity of the indications at the H9 weld to the vessel, although unlikely, the potential impact of propagation into the vessel must be considered. This letter report provides a qualitative discussion as to why the impact of these indications on the reactor pressure vessel is not a concern. The evaluation considers the material characteristics, inspection information, fracture mechanics and stress information to justify the conclusion.

CRACK PROPAGATION AND HYDROGEN WATER CHEMISTRY CONSIDERATIONS

Crack Propagation into Low Alloy Steels

Significant crack growth into ferritic carbon steel components (e.g. feedwater piping) and ferritic low alloy steel components (e.g. unclad regions of the pressure vessel) associated with propagating cracks in austenitic stainless steel cladding or Alloy 182 attachments, by environmentally-assisted cracking (EAC) in BWRs has been very infrequent compared to the incidence rate observed in BWR austenitic alloys such as Type 304 and 316 stainless steels and in creviced Alloy 600 and its weld metals, Alloys 182 and 82.

There are fundamental reasons why it is remarkably difficult to sustain crack propagation in the carbon steel and low alloy steel/BWR environmental systems under good (e.g., low chloride) water chemistry and non-dynamic loading conditions. The very isolated EAC incidents in carbon steel and low alloy steel that have been reported have been associated with dynamic loading during plant startup or relatively low frequency cyclic loading due, for instance, to thermal stratification in piping or inadequate mixing of hot and "cold" coolant streams [3, 4]. The morphology of this cracking is generally transgranular, although in a very few isolated incidents the cracking morphology may be intergranular depending on the stressing mode and/or environmental conditions.

Unlike the case for austenitic stainless steels and austenitic nickel base alloys, it is the formation of sulfur anions (e.g., S^{2-}) at the crack tip that is a dominant factor in determining the kinetics of crack tip oxidation and hence cracking in carbon steels and low alloy steels [5]. The dissolution of manganese sulfide (MnS) precipitates in the steel is a prime source of this anionic impurity. The maintenance of a significant dissolved S^{2-} activity at the crack tip requires that the crack be propagating at a critical rate to introduce dissolvable MnS precipitates to the crack tip environment at a rate sufficient to counteract the diffusional flux of anions out of the crack, Figure 5 [6]. This critical crack propagation rate is in the range 10^{-5} to 10^{-6} cm/s where the specific rate depends on the MnS precipitate size and distribution, the corrosion potential and the water flow rate. If this propagation rate cannot be maintained then crack arrest is predicted and observed as shown in Figure 6 [7].

It is important to note that the above discussion concerning the difficulty of crack propagation in low alloy steels does not even consider the benefits of the actual Monticello low corrosion potential environment that will be discussed in the next section.

Mitigation Effectiveness of Hydrogen Water Chemistry for BWR Core Shrouds

Aside from the fact that operating experience (OE) from defected RPV stainless steel cladding and cracked Alloy 182 weld in access hole covers in BWRs has not lead to significant penetration into the low alloy steel, it is perhaps the Monticello lower plenum environment itself that supports this hypothesis. For a point of reference, the lower plenum or lower vessel head region of the Monticello BWR is defined as the volume from the underside of the shroud support plate to the bottom of the active fuel (BAF) that includes the underside of the shroud support plate welds H8, H9 and H10, Figures 1 and 2 [8]

Monticello is currently a moderate hydrogen water chemistry (HWC-M) BWR with plans to go to on-line noble chemistry (OLNC) in 2013. Visual and UT examinations of BWR shrouds have been conducted since the early 1990s [9]. Results of these inspections have shown the shroud to be one of the most frequently cracked and actively cracking components in BWRs. To reduce crack growth rates and crack initiation in the shroud, as well as in other internal components, all U.S. BWRs as of 2004 achieved some level of IGSCC mitigation through HWC. This mitigation occurred either at HWC-M levels or at low HWC levels with noble metals chemical addition (NMCA) or on-line noble chemistry (OLNC).

Review of shroud UT re-inspection results from eight core shrouds provides important quantitative information on the effectiveness of plant mitigation activities. The crack growth rate examination results discussed in BWRVIP-174 support the effectiveness of HWC-M with the following key observations [9]:

- All mitigation methods show crack growth rate reductions when compared to normal water chemistry (NWC) crack growth rates.
- Mitigation reduces lengthening crack growth rates by 40-50% overall, with NMCA plants showing the most crack growth rate reduction.
- Mitigation reduces deepening crack growth rates by 60-70% overall, with HWC-M plants showing the most crack growth rates reduction.
- OD indications show the lowest crack growth rates in both lengthening and deepening, although the difference for lengthening is considerably greater than for deepening.

Mitigation of Stub Tube Cracking at Santa María de Garoña

The crack growth due to IGSCC of control rod drive (CRD) stub tubes in the lower plenum of the Santa María de Garoña BWR has been analyzed as based on the comparison between the data collected through the inspections carried out during refueling outages since 1988 and the estimations of applying the BWRVIP-14 predictive crack growth rate models [10] using as inputs the results of the radiolysis model of Santa María de Garoña [11].

The statistical study of the actual crack growth data indicated that there is a clear relationship between the water chemistry and the rate of progression of the indications in the lower plenum at Santa María de Garoña [11]. Thus, for only low HWC operation, the crack growth rate corresponding to a confidence level of 50% is equal to 0.37 mm/year (1.66×10^{-6} in/hour), while for the HWC-M operation that value decreases to 0.10 mm/year (4.49×10^{-7} in/hour), a FOI of 3.7. If the analysis is performed for a confidence level of 95%, the corresponding crack growth rate values are 1.51 mm/year (6.79×10^{-6} in/hour) for the LHWC period and 0.35 mm/year (0.35×10^{-6} in/hour) for HWC-M operation, a FOI of 4.3. The results of this evaluation clearly indicate that HWC-M mitigates IGSCC in the lower plenum in the Santa María de Garoña BWR, which provides insight in general to all BWRs.

Other In-Plant Data

Figure 7 presents in-plant reversing DC potential drop (DCPD) crack growth rate data from a double cantilever beam (DCB) furnace sensitized stainless steel specimen monitored directly in the bottom head drain line (BHDL) of an operating BWR with and without HWC [12]. The DCB specimen was located inside a flange directly in the bottom head drain line flow stream. This location closely represents the water chemistry and ECP of the lower plenum region of this particular BWR. The transit time of water between the lower plenum and the crack growth measurement location in the bottom drain line is approximately 7 to 12 seconds, and hence is reasonably representative of the lower plenum water chemistry, with little decomposition of hydrogen peroxide. The crack growth rate under HWC was a factor of 22 lower compared with the NWC condition.

Because of the presence of a long term mitigating environment in the lower plenum of the Monticello RPV, it is reasonable to postulate that the observed cracking was present since before HWC was implemented at the plant. That observation would suggest that these indications have likely been dormant following the HWC treatment because of the mitigating environment.

As discussed above, the environment in the lower plenum to which these indications are exposed results in excellent protection against future SCC growth. Recognizing that any future growth is expected to be quite small with continued water chemistry control, the following discussion supports the conclusion that growth into the vessel or shroud will not occur.

STRESS AND FRACTURE MECHANICS CONSIDERATIONS

The stress distribution in the vicinity of the susceptible material is also very important to subsequent propagation behavior. Per BWRVIP-38, CB&I RPVs were post weld heat treated (PWHT) prior to fabrication and prior to the attachment of the shroud support structure. Thus, weld residual stress, which would be relieved to some extent by the PWHT had it been performed after the fabrication, is present at the H8 and H9 weld locations.

Reference 13 shows several examples of stress distributions in the vessel due to attachment welds including a shroud support-to-vessel attachment weld. One of the characteristics of all of these attachments (non-PWHT'd) is that the residual stress does not penetrate into the wall of the vessel significantly dropping rapidly a short distance into the vessel inside surface. Thus, disregarding the environmental benefits of HWC-M, there is limited residual stress penetration into the vessel wall contributing to the conclusion that the vessel would not be impacted. This conclusion applies regardless of the orientation of the stress (circumferential or axial).

Compared to the magnitude of the residual stress from the attachment weld, all other stresses are significantly lower. The hoop stress due to pressure, which would drive an axial flaw (recall the indications are circumferentially oriented and are located in susceptible material downward through the thickness of the shroud support plate) in the vessel, would require that the flaws turn from growing downward through the more susceptible material to a vertical orientation such that the RPV pressure hoop stress could provide a driving force.

MATERIAL CONSIDERATIONS

If crack growth were to occur (assuming the presence of an aggressive environment instead of the mitigating environment in the lower plenum of Monticello) the direction of the flaw growth would be governed by the stress pattern and orientation of susceptible material. In the case of Monticello's H8 and H9 local geometry, Alloy 182 is present through the entire thickness of the shroud support plate (see Figure 2). On the H8 side, the Alloy 182 attaches the Alloy 600 plate to the Alloy 600 Shroud cylinder. On the H9 side, the Alloy 182 weld attaches the Alloy 600 plate to the Alloy 182/82 weld pad that is welded to the vessel wall. For a the normal water chemistry environment (NWC) in the BWR, Alloy 182 is considered more susceptible to cracking than the Alloy 600 plate. This fact is supported by the observation of cracking in the Alloy 182 at both the H8 and H9 locations.

The observation of the cracking in the Alloy 182 weld metal is consistent based upon the relative susceptibility of the neighboring materials. Since the Alloy 182 is present through the thickness of the shroud support plate (see Figure 2), it is expected that solely based on the susceptibility of the materials involved, that the cracking would be most severe in the most susceptible material, the Alloy 182, and thus continue through the thickness of the shroud support plate.

Note that this location is also in a low fluence area. Reduction of fracture toughness in the vessel material due to fluence is not a concern.

INSPECTION CONSIDERATIONS

The discussion provided above, based on historical operating experience, analytical understanding, measurement and testing, provides a solid justification that propagation into the vessel is not a concern. However, validation through some sampling of the actual location of focus in the vessel is very valuable. During the current outage, XCEL performed volumetric inspection of the N1B nozzle. During this inspection, a 72 inch circumferential segment of the vessel located along the shroud support attachment elevation was also performed. This examination was capable of detecting flaws in the vessel if they were present. Results of this inspection showed no evidence of indications in the vessel that might be associated with the shroud support attachment weld.

This inspection was performed along a stretch of the attachment weld that was known to contain visual signs of indications in the attachment weld. Thus, the absence of any sign of indications in the vessel provides evidence that this in fact has not occurred, thereby confirming the conclusions discussed above.

Continued monitoring of the indications during future operation will provide assurance that the cracking is minimal.

CONCLUSIONS

The above discussion and present results suggest the following conclusions relative the possibility of cracks in Alloy 182 propagating from the Alloy 182 in to the low alloy steel pressure vessel:

1. Significant crack growth in low alloy steel is extremely difficult to obtain in the BWR environment since it requires dynamic loading during plant startup or relatively low frequency cyclic loading due, for instance, to thermal stratification in piping or inadequate mixing of hot and "cold" coolant streams.
2. The lower plenum environment at Monticello, i.e., HWC-M, mitigates crack growth in all BWR structural materials such as austenitic stainless steel, nickel-base alloys (e.g., Alloy 182) and ferritic materials such as RPV low alloy steel.
3. Minimal crack propagation, if any, would be expected in the low alloy steel even if the presumed crack could change direction under expected loading conditions present and propagate toward the vessel.
4. Volumetric inspection of the vessel adjacent to the attachment weld (72" circumferential segment) confirmed that no indications exist in the vessel at the examined locations.

Therefore, it is concluded that the visually observed crack like indications do not pose a concern for the RPV.

Prepared by: [signature] 4/20/11
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Senior Consultant

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Anthony Giannuzzi, Ph.D., PE — Date
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Approved by: [signature] 4/20/11
Marcos L. Herrera, PE — Date
Vice-President/Senior Associate

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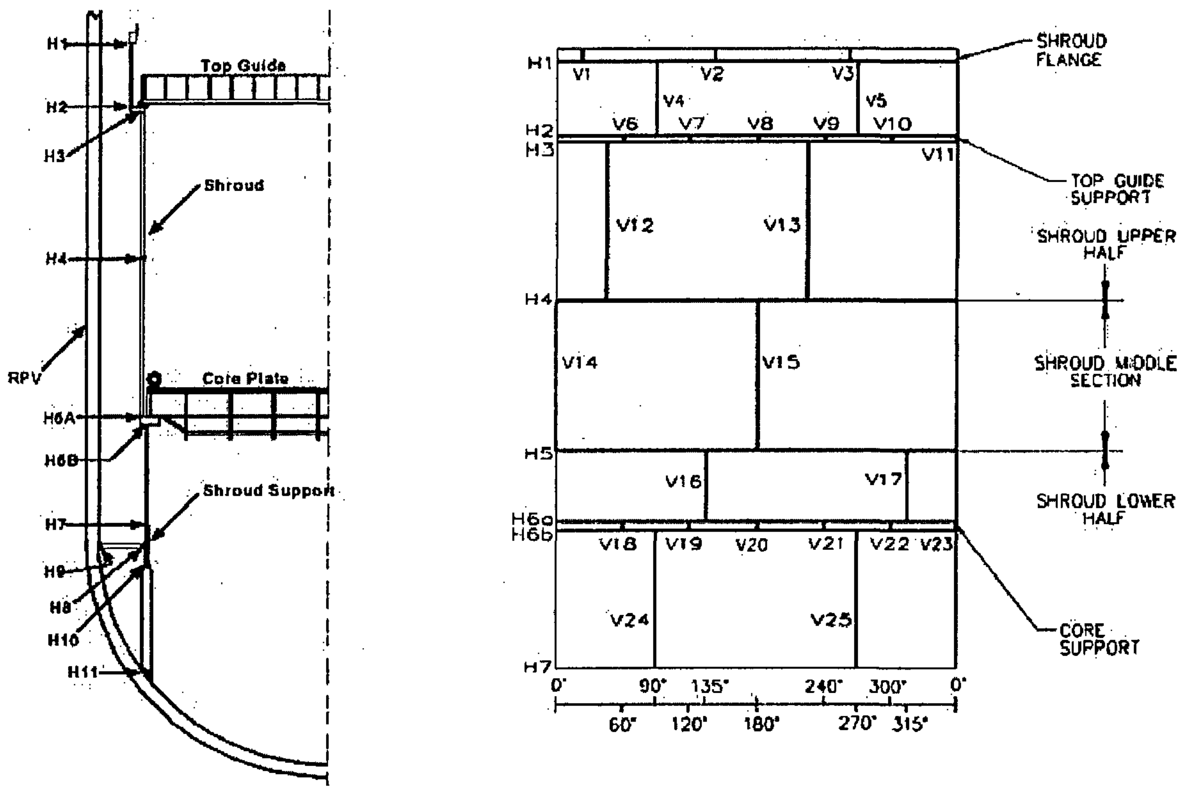

Figure 1. Sketch of Shroud with Typical Weld Locations

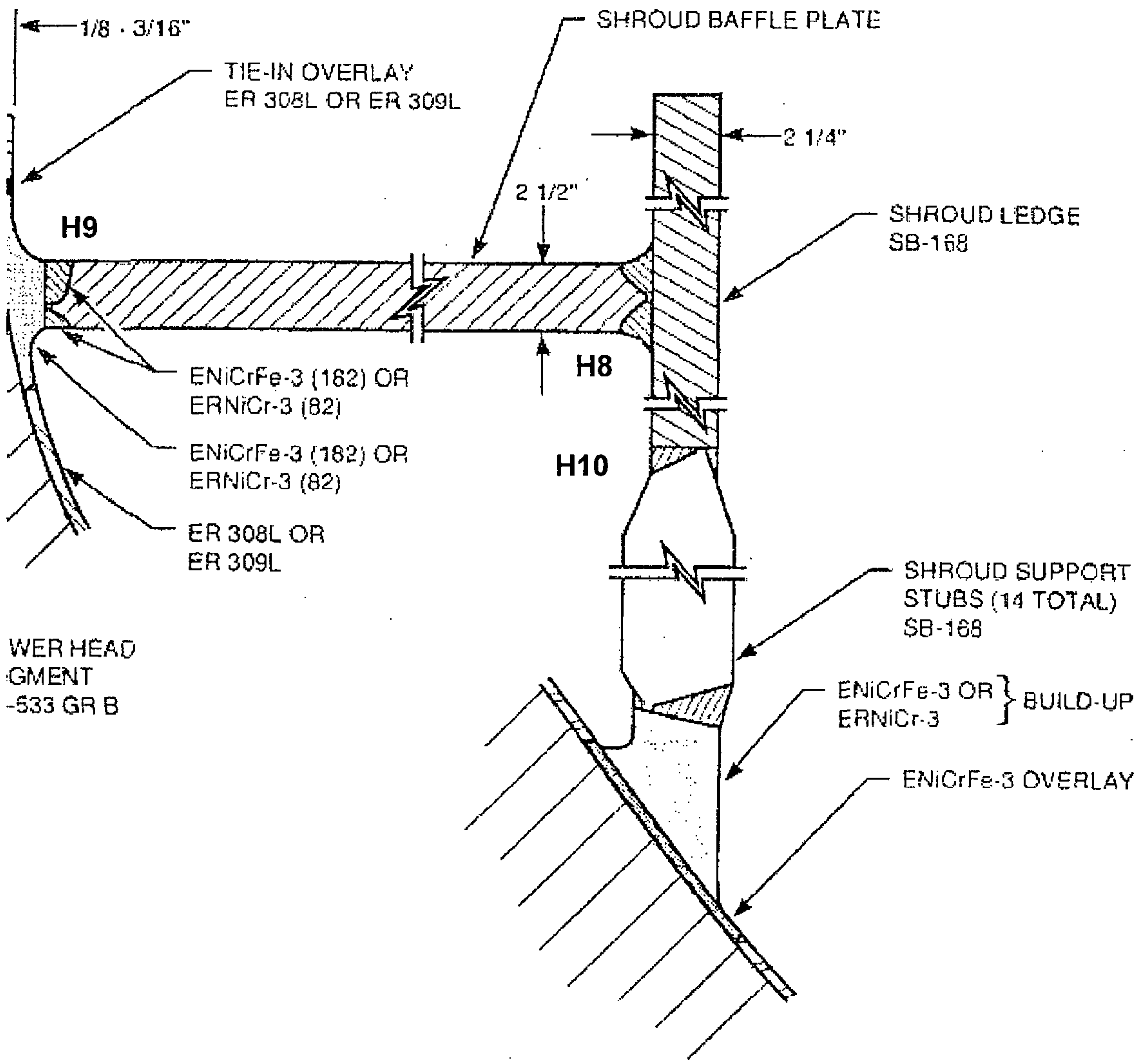

Figure 2: CBIN/CB&I Vessel Shroud Support Structure Attachment Configuration [2]

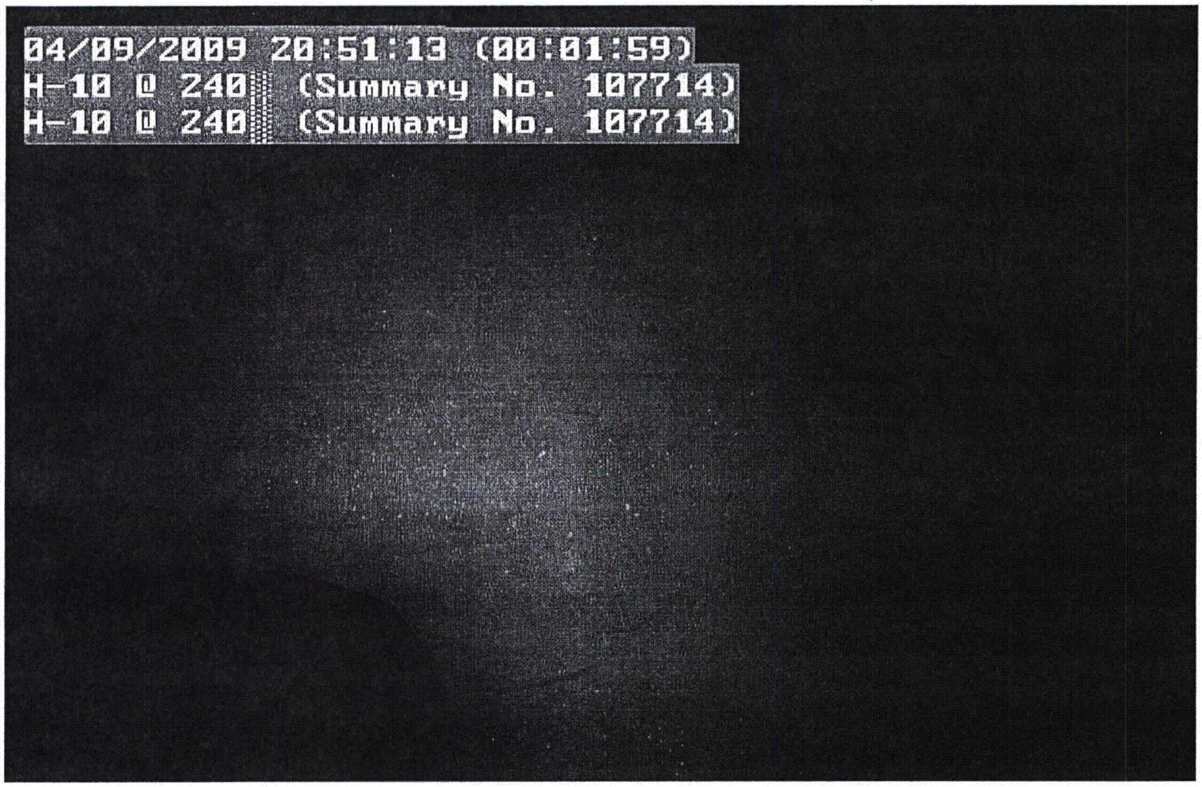

Figure 3. Indication Found in Shroud Support Leg H-10 at 240° [1]

Figure 4. Indications at the H9 Weld

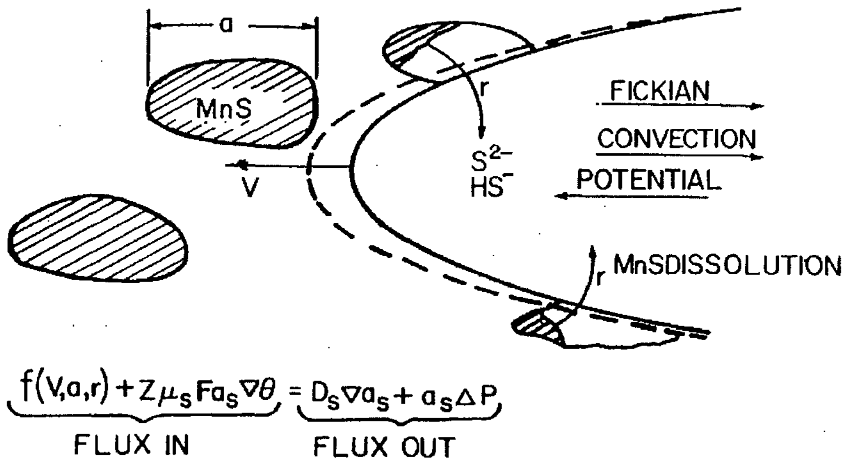

Figure 5. Schematic of Crack Tip in a Low Alloy Steel, Illustrating the Geometrical and Transport Factors Relevant to the Maintenance of a Dissolved S^{2-} Species at the Crack Tip [5]

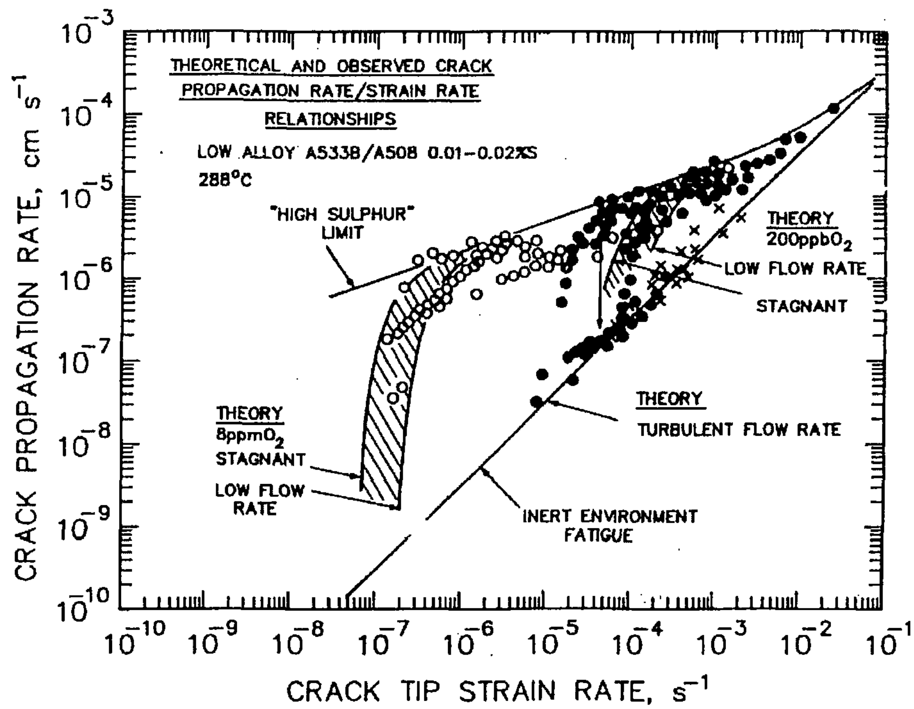

Figure 6. Observed and Theoretical Crack Propagation Rate/Crack Tip Strain Rate Relationships for Low Alloy Steel, Indicating the Onset of Crack Arrest as the Crack Propagation Rate Falls Below a Critical Value [7]

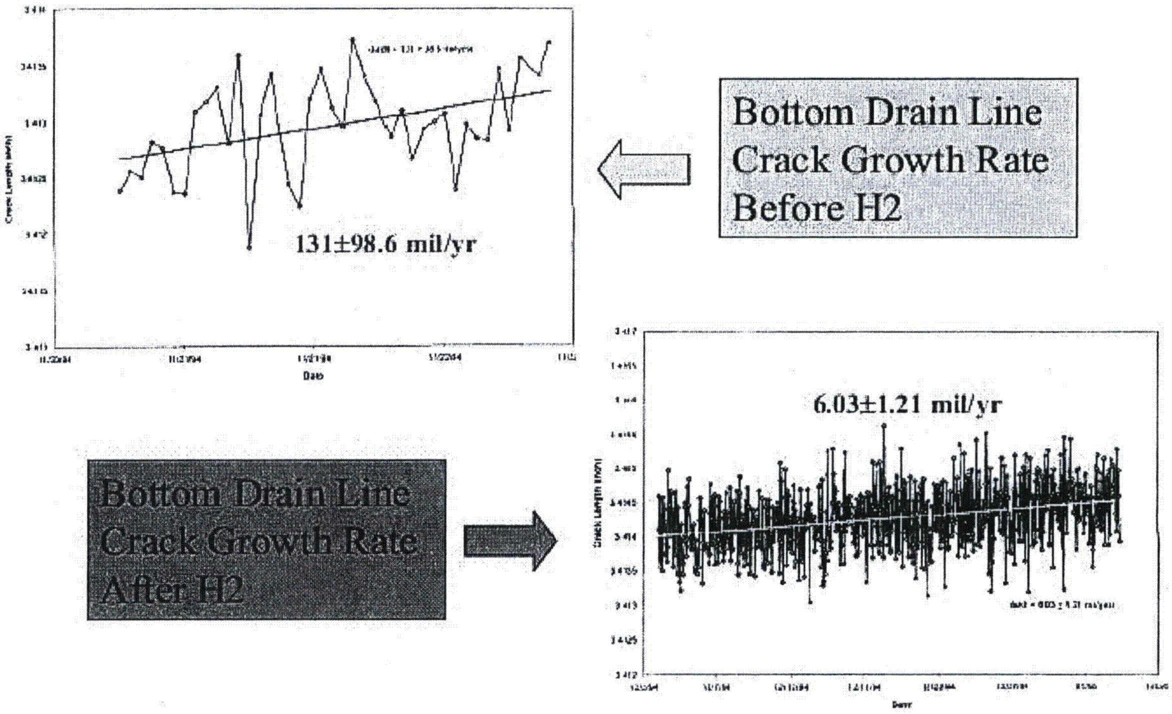

Figure 7. HWC Produces a Factor of 22 Reduction in Crack Growth Rate in the Lower Plenum for a Furnace Sensitized Type 304 Stainless Steel DCB Specimen [12]

ENCLOSURE 5

MONTICELLO NUCLEAR GENERATING PLANT

SUPPLEMENTAL INFORMATION REGARDING CYCLE 25 INSERVICE INSPECTION SUMMARY REPORT – CORE SHROUD SUPPORT FLAW EVALUATION

SIA AFFIDAVIT

(2 pages follow)

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May 24, 2013

AFFIDAVIT

I, Marcos Legaspi Herrera, state as follows:

(1) I am a Vice President of Structural Integrity Associates, Inc. (SI) and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in SI Calculation 1100560.301, Rev. 0, "Evaluation of the Monticello Shroud with Indications at Welds H8 and H9". This calculation contains information of a proprietary and confidential nature and is of the type customarily held in confidence by SI 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 calculation as proprietary and confidential.

Paragraph 3 of this Affidavit provides the basis for the proprietary determination.

(3) SI is making this application for withholding of proprietary information on the basis that this material meets the exemption of disclosure requirement set forth in NRC Regulation 10 CFR 2.390(a)(4) pertaining to "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is herein sought is considered proprietary for the following reasons:

a) 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; and

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

Public disclosure of the information sought to be withheld is likely to cause substantial harm to SI.

I declare under penalty of perjury that the above information and request are true, correct, and complete to the best of my knowledge, information, and belief.

Executed at San Jose, California on this 29th day of May, 2013.

Marcos Legaspi Herrera, P.E.
Vice President
Nuclear Plant Services

State of California

County of Santa Clara

Subscribed and sworn to (or affirmed) before me

on this 29th (Date) day of May (Month), 2013 (Year), by

(1) Marcos Legaspi Herrera (Name of Signer)

proved to me on the basis of satisfactory evidence to be the person who appeared before me (.) ~~(,)~~
~~(and~~

(2) ______ (Name of Signer)

proved to me on the basis of satisfactory evidence to be the person who appeared before me.)

C. METZGER
Commission # 1866327
Notary Public - California
Santa Clara County
My Comm. Expires Sep 27, 2013

Place Notary Seal and/or Stamp Above

Signature ______ (Signature of Notary Public)

ENCLOSURE 6

MONTICELLO NUCLEAR GENERATING PLANT

SUPPLEMENTAL INFORMATION REGARDING CYCLE 25 INSERVICE INSPECTION SUMMARY REPORT – CORE SHROUD SUPPORT FLAW EVALUATION

EPRI AFFIDAVIT

(3 pages follow)

ELECTRIC POWER RESEARCH INSTITUTE

NEIL WILMSHURST
Vice President and
Chief Nuclear Officer

June 6, 2013

Document Control Desk
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Request for Withholding of the following Proprietary Information Included in:

"Evaluation of Shear Capacity of Monticello Shroud Welds H8 and H9-2011 RFO25" contained in calculation package, File No: 1100626.301, Project No: 1100626

To Whom It May Concern:

This is a request under 10 C.F.R. §2.390(a)(4) that the U.S. Nuclear Regulatory Commission ("NRC") withhold from public disclosure the report identified in the enclosed Affidavit consisting of the proprietary information owned by Electric Power Research Institute, Inc. ("EPRI") identified in the attached report. Proprietary and non-proprietary versions of the Report and the Affidavit in support of this request are enclosed.

EPRI desires to disclose the Proprietary Information in confidence to assist the NRC review of the enclosed submittal to the NRC by Xcel Energy. The Proprietary Information is not to be divulged to anyone outside of the NRC or to any of its contractors, nor shall any copies be made of the Proprietary Information provided herein. EPRI welcomes any discussions and/or questions relating to the information enclosed.

If you have any questions about the legal aspects of this request for withholding, please do not hesitate to contact me at (704) 704-595-2732. Questions on the content of the Report should be directed to Andy McGehee of EPRI at (704) 502-6440.

Sincerely,

Together . . . Shaping the Future of Electricity

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ELECTRIC POWER RESEARCH INSTITUTE

AFFIDAVIT

RE: Request for Withholding of the Following Proprietary Information Included In:

"Evaluation of Shear Capacity of Monticello Shroud Welds H8 and H9-2011 RFO25" contained in calculation package, File No: 1100626.301, Project No: 1100626

I, Neil Wilmshurst, being duly sworn, depose and state as follows:

I am the Vice President and Chief Nuclear Officer at Electric Power Research Institute, Inc. whose principal office is located at 1300 W WT Harris Blvd, Charlotte, NC. ("EPRI") and I have been specifically delegated responsibility for the above-listed report that contains EPRI Proprietary Information that is sought under this Affidavit to be withheld "Proprietary Information". I am authorized to apply to the U.S. Nuclear Regulatory Commission ("NRC") for the withholding of the Proprietary Information on behalf of EPRI.

EPRI Information is identified by a solid line on the right margin. Tables containing EPRI proprietary information are also identified with a solid line at the right margin.

EPRI requests that the Proprietary Information be withheld from the public on the following bases:

Withholding Based Upon Privileged And Confidential Trade Secrets Or Commercial Or Financial Information:

a. The Proprietary Information is owned by EPRI and has been held in confidence by EPRI. All entities accepting copies of the Proprietary Information do so subject to written agreements imposing an obligation upon the recipient to maintain the confidentiality of the Proprietary Information. The Proprietary Information is disclosed only to parties who agree, in writing, to preserve the confidentiality thereof.

b. EPRI considers the Proprietary Information contained therein to constitute trade secrets of EPRI. As such, EPRI holds the Information in confidence and disclosure thereof is strictly limited to individuals and entities who have agreed, in writing, to maintain the confidentiality of the Information.

c. The information sought to be withheld is considered to be proprietary for the following reasons. EPRI made a substantial economic investment to develop the Proprietary Information and, by prohibiting public disclosure, EPRI derives an economic benefit in the form of licensing royalties and other additional fees from the confidential nature of the Proprietary Information. If the Proprietary Information were publicly available to consultants and/or other businesses providing services in the electric and/or nuclear power industry, they would be able to use the Proprietary Information for their own commercial benefit and profit and without expending the substantial economic resources required of EPRI to develop the Proprietary Information.

d. EPRI's classification of the Proprietary Information as trade secrets is justified by the Uniform Trade Secrets Act which California adopted in 1984 and a version of which has been adopted by over forty states. The California Uniform Trade Secrets Act, California Civil Code §§3426 – 3426.11, defines a "trade secret" as follows:

"'Trade secret' means information, including a formula, pattern, compilation, program device, method, technique, or process, that:

(1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and

(2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy."

e. The Proprietary Information contained therein are not generally known or available to the public. EPRI developed the Information only after making a determination that the Proprietary Information was not available from public sources. EPRI made a substantial investment of both money and employee hours in the development of the Proprietary Information. EPRI was required to devote these resources and effort to derive the Proprietary Information. As a result of such effort and cost, both in terms of dollars spent and dedicated employee time, the Proprietary Information is highly valuable to EPRI.

f. A public disclosure of the Proprietary Information would be highly likely to cause substantial harm to EPRI's competitive position and the ability of EPRI to license the Proprietary Information both domestically and internationally. The Proprietary Information can only be acquired and/or duplicated by others using an equivalent investment of time and effort.

I have read the foregoing and the matters stated herein are true and correct to the best of my knowledge, information and belief. I make this affidavit under penalty of perjury under the laws of the United States of America and under the laws of the State of California.

Executed at 1300 W WT Harris Blvd being the premises and place of business of Electric Power Research Institute, Inc.

Date: 6-6-2013.

[signature]

Neil Wilmshurst

(State of North Carolina)
(County of Mecklenburg)

Subscribed and sworn to (or affirmed) before me on this 6th day of June, 2013, by Neil Wilmshurst, proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

Signature Deborah H. Rouse (Seal)

My Commission Expires 2nd day of April, 2016.