Omaha Public Power District
444 South 16th Street Mall
Omaha, NE 68102-2247

LIC-15-0070
May 16, 2015

10 CFR 50.55a

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

Fort Calhoun Station, Unit No. 1
Renewed Facility Operating License No. DPR-40
NRC Docket No. 50-285

Subject: Omaha Public Power District (OPPD) Response to NRC Request for Additional Information Regarding Relief Request RR-14

References:
1. Letter from OPPD (L. P. Cortopassi) to NRC (Document Control Desk), "Relief Request Number RR-14, Request for Relief from Paragraph -3142.1(c) of ASME Code Case N-729-1 for Reactor Vessel Head Penetration Nozzle Welds," dated May 9, 2015 (LIC-15-0066)
2. E-mail from NRC (C. F. Lyon) to OPPD (B. R. Hansher), "Fort Calhoun Station, Unit No.1- Request for Additional Information for Fort Calhoun Relief Request RR-14, Reactor Vessel Head Inspections," dated May 11, 2015
3. E-mail from NRC (C. F. Lyon) to OPPD (B. R. Hansher), "RAIs for RR-14 (TAC No. MF6206)," dated May 12, 2015
4. Letter from OPPD (L. P. Cortopassi) to NRC (Document Control Desk), "Omaha Public Power District (OPPD) Response to NRC Request for Additional Information Regarding Relief Request RR-14," dated May 13, 2015 (LIC-15-0069)
5. E-mail from NRC (C. F. Lyon) to OPPD (B. R. Hansher), "FCS: RAI Number 2 for RR-14, RVH Leakage/ASME Code Case N-729-1 (TAC No. MF6206)," dated May 15, 2015

The purpose of this letter is to provide supplemental information to facilitate the NRC staff's review of Relief Request RR-14 (Reference 1) and the Omaha Public Power District (OPPD) response (Reference 4) to the NRC request for additional information (RAI) (Reference 2), as modified by Reference 3. Specifically, this letter is responding to the Reference 5 NRC RAI. Attachment 1 contains an executive summary of the inspection of the reactor vessel head and dispositioning of as found conditions during Refueling Outage 27.

The photographs requested in NRC Question 1 will be submitted under separate transmittal. Attachments 2, 3, and 4 respond to the remaining NRC questions.

Please note that Attachment 2 contains regulatory commitments that supersede the commitment made in Reference 4.

If you should have any questions regarding this submittal or require additional information, please contact Mr. Bill R. Hansher at 402-533-6894.

Respectfully,

Louis P. Cortopassi
Site Vice President and CNO

LPC/KGM/mle

Attachments:
1. Executive Summary
2. OPPD Response to NRC Request for Additional Information Regarding Relief Request RR-14
3. As Left Condition of Penetrations
4. Dominion Engineering, Inc., Technical Note TN-3941-00-01, "Response to Request for Additional Information Question #6 Regarding Fort Calhoun Relief Request RR-14," Revision 1, May 2015

c: M. L. Dapas, NRC Regional Administrator, Region IV
C. F. Lyon, NRC Senior Project Manager
S. M. Schneider, NRC Senior Resident Inspector

Executive Summary

FCS Radiation Protection department personnel performed the inspection of the Reactor Vessel Head (RVH) as part of containment surveys/inspections. These surveys/inspections provided evidence that leakage from mechanical connections above the reactor vessel head travelled down onto the RVH and its insulation. The Boric Acid Program Owner attributed this leakage to the Component Cooling Water (CCW) Flex Hose leak near Control Element Drive Mechanism (CEDM) RC-10-03, and leakage from the Thermowell for CEDM 10-24, the RVH Vent Valve packing RC-100, and Incore Instrumentation ICI-44 GrayLock connection.

The Level II QC inspector performed his initial assessment in accordance with Work Order 551120-01 and the FCS Inservice Inspection (ISI) Program. This inspection incorrectly determined relevant and non-relevant locations based on visual examination and chemical testing of the deposits. This is not in accordance with the examination requirements of ASME Code Case N-729-1 (Condition Report 2015-05870).

OPPD concluded from subsequent examinations by the Boric Acid Program Owner that none of the observed deposits came from the penetration nozzles and no wastage of the reactor vessel head material has occurred. As described in the attachment, OPPD is requesting relief from the requirement for a supplemental examination due to hardship without a compensating increase in the level of quality or safety. Relief is requested in accordance with 10 CFR 50.55a(z)(2).

The Boric Acid Program Owner and the Level 2 VT Inspector performed visual examinations to examine the bare metal RVH upper head surface for conditions that would indicate degradation of the upper head or potential nozzle penetration leakage. "As found" foreign material was removed to the extent necessary that allowed adequate examinations and evaluation of degradation, and a subsequent Visual Examination (VE). Additionally, an independent evaluation and inspection was performed by a Boric Acid Program Subject Matter Expert, from another utility, who confirmed the results of the evaluation. Pictures obtained after multiple cleanings are attached to document the as-left condition of the RVH. There is no evidence of nozzle leakage or vessel head wastage.

In addition, the results of chemistry sampling of material collected from the RVH are also included to demonstrate that the "as found" foreign material is consistent with a leak from the CEDM RC-10-03 Flex Hose. Chemistry analyzed these samples and determined they had high pH (>9.0) and tested positive for the presence of the Component Cooling Water (CCW) corrosion products inhibitor tolyltriazole.

The Alloy 690 nozzle base and Alloy 52/152 weld materials used in the replacement RVH provide for a superior reactor coolant system pressure boundary where the potential for PWSCC has been shown by analysis and by years of positive industry experience to be unlikely.

In conclusion, the minor staining and deposits that remain are the result of leakage above the RVH. Chemistry data confirms this conclusion. The superior Alloy 690 material is demonstrated to resist leakage. No reactor head degradation or wastage has been identified. This conclusion is supported by the pictures attached to this request. A thorough cleaning of the head has been completed to address the spillage from overhead and provides a baseline reference for future inspections.

Based on this information and the proposed compensatory measures Fort Calhoun believes this is adequate basis for relief.

OPPD Response to NRC Request for Additional Information Regarding Relief Request RR-14

REQUEST FOR ADDITIONAL INFORMATION
RELIEF REQUEST NUMBER RR-14
ALTERNATIVE INSPECTION OF REACTOR VESSEL
CLOSURE HEAD WITH RESPECT TO ASME
CODE CASE N-729-1 AS CONDITIONED BY 10CFR50.55A
OMAHA PUBLIC POWER DISTRICT
DOCKET NUMBER 50-285

By letter dated May 9, and supplemented May 13, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML15129A004 and ML15135A387, respectively), Omaha Public Power District submitted RR-14 for Fort Calhoun Station, Unit 1.

The NRC staff has reviewed the information provided in your application and determined that the additional information below is required in order to complete its formal review.

NRC Question

1. **Please provide the photographs and descriptions of all nozzles for which foreign material was identified. Please ensure that the photos cover 360 degrees for each nozzle.**

OPPD Response

Photographs will be submitted under separate transmittal. Descriptions of penetrations are contained in Attachment 3.

NRC Question

2. **Please provide the calculations supporting the time to nozzle ejection included in previous submissions.**

OPPD Response

Please see Attachment 4, which contains Technical Note TN-3941-00-01, Revision 1. The document was revised to add discussion to the crack growth time assessment of Section 3.1 including:

- Arrhenius temperature adjustment
- Calculation of critical crack length
- Conservative treatment of stress intensity factor

NRC Question

3. **For each nozzle which exhibited foreign material near the annulus, including staining, please identify the source of the material and provide a justification for the leakage being from that source (e.g., a chemical and/or isotopic analysis of the material at the annulus showing the material to be inconsistent with RCS chemistry; evidence that the material is non-adherent, or evidence that a leakage path exists from a point above each nozzle under consideration to a point below the nozzle such that it is reasonable to conclude that fluid would have entered the annulus of the nozzle under consideration).**

OPPD Response

Attachment 3 provides a description of the as left condition of individual penetrations.

A summary of pertinent chemistry results showing that the material is inconsistent with RCS chemistry is shown below.

1. Samples were taken from around the base of select nozzle penetrations but not all penetrations on the Reactor Vessel Head (RVH) upon insulation removal during RFO 27. The samples yielded the following results:

   - The testing completed were analyses for the presence of boron, pH, tolyltriazole and isotopic concentrations.
   - The boric acid, used for reactivity control in the RCS contains boron. The CCW corrosion inhibitor additive, CorrShield NT4204 contains sodium borate. The analyses performed at FCS for boron cannot differentiate between boron and borate, both analysis results are calculated in units of ppm boron. However, historically analytical results of known CCW deposits have shown boron up to approximately 200 ppm while analysis of known boric acid samples range up to approximately 900 ppm and much greater.
   - The pH is another indicator of the type of boron (elemental boron or borate). The pH of sample with only boric acid are typically pH <6. All samples that had a sufficient quantity of deposits to conduct a pH analysis had pH values >9, which would be improbable if boric acid were the predominate species.
   - Analyses of the deposits identified the presence of totyltriazole in the samples. Tolyltriazole only originates in the CCW system.

Analysis performed on the samples provided could not conclusively determine that the analyzed boron was a result of "minor contamination from leakage of RC-100 packing and ICI Port #44 mechanical connection. However, the presence of tolytriazole, combined with low levels of boron, is consistent with previously analyzed CCW leakage samples. The sum of the sample evidence shows that the predominate plant species in the deposits is not boric acid. If present, it would have to be a minor constituent.

2. Smear samples conducted on May 14, 2015, on ICI nozzle penetrations had the following results

- Visual evidence of the corrosion products hematite and magnetite. The smears were not analyzed for iron, since they would have to be dissolved, and a decision was made to maintain them.
- Short term age determination was calculated using the ratio of the corrosion product isotopes, Nb-95 and Zr-95. In smears where both isotopes were identified, this ratio was determined. The calculations yielded sample deposit ages in the range of 33 - 82 days with an average of 61 days.
- Similarly, the intermediate term age determination was calculated using Co-60/Co-58 ratios. In smears where both isotopes were identified, this ratio was determined. The calculations yielded sample deposit ages ranging from 267 - 547 days with an average of 379 days. Ratios from the deposit sampling conducted on 5/2/15 and 5/6/15 displayed similar analytical results.
- Long term age determination was calculated using Co-60/Mn-54 ratios. In smears where both isotopes were identified, this ratio was determined. The calculations yielded sample deposit ages between 2-4 years. Long term aging results can also be determined using Cs-134 and Cs-137 ratios. However Cs-134 has only been identified intermittently during recent online RCS sampling and was not identified in the smears or deposits. Cs-137 was identified at concentrations equal to or greater than the corrosion products, indicating longer term affects
- Smears from the CEDM's and head vent displayed similar ratios for each type of age calculation.

3. The high pH (>9.0) and presence of the CCW corrosion inhibitor tolyltriazole indictates that the majority of the deposit was CCW related. The intermediate and short term aging data, dictate some leakage from this cycle, probably from the last half to last third of cycle, is present. Long term age analysis and high Cs-137 concentration dictate that longer term leakage has impacted the deposits/smears as well.

NRC Question

4. **The EPRI publication "Materials Reliability Program: Reactor Vessel Closure Head Penetration Safety Assessment for U.S. Pressurized Water Reactor (PWR) Plants (MRP-110) Evaluations Supporting the MRP Inspection Plan" identifies the leakage required to cause wastage of the carbon steel to be caused by a leak rate of 0.1 gpm. Please include the following as compensatory measures in the proposed alternative, or provide a technical basis as to why the following compensatory measures would not be required to assure that less than 0.1 gallon per minute (gpm) is leaking through any control rod drive or ICI nozzles:**

    a. **The use of administrative controls such that the plant would shut down on an unidentified leak rate greater than 0.1 gpm above a stable baseline, or the use of radiation monitoring equipment near the head and administrative controls over the equipment to shut down the plant at detected radiation levels equivalent to a leak rate of 0.1 gpm above a stable baseline.**
    b. **Perform a bare-metal visual inspection on the upper head on the first outage of greater than 72 hours which occurs after at least 4 months of operation in accordance with the criteria contained in ASME code case N-729-1.**
    c. **At the next refueling outage, conduct UT/surface examinations of all nozzles.**

OPPD Response

Commitments for the necessary compensatory measures are contained in the regulatory commitments table shown below. Please note that the commitment for item b was revised for industrial and radiological safety concerns to state that the bare-metal visual inspection of the reactor vessel head (RVH) will occur during the first Cold Shutdown outage of greater than 72 hours that occurs after at least 4 months of operation.

Regulatory Commitments Table

Commitment	Committed Date or Outage	Commitment Type	
		One-Time Action (Yes/No)	Programmatic (Yes/No)
OPPD will use administrative controls such that at an unidentified leak rate increase of greater than 0.1 gpm above a stable baseline, actions will be taken to identify the source of the leakage. If the source is not identified within 24 hours, actions will be taken to shut the plant down. (**AR 63850**)	During Cycle 28	Yes	No
OPPD will perform a bare-metal visual inspection on the upper RVH in accordance with the criteria contained in ASME Code Case N-729-1 on the first Cold Shutdown of greater than 72 hours that occurs after at least 4 months of operation. (Note this commitment supersedes OPPD's previous commitment contained in Reference 4.) (**AR 63850**)	During Cycle 28	Yes	No
OPPD will conduct UT/surface examinations of all RVH nozzles at the next refueling outage. (**AR 63850**)	FCR28	Yes	No

NRC Question

5. **Please provide the radiation dose estimate for completing supplemental UT/surface examinations, including the justification for the estimate. Also, please provide the dose estimate for the supplemental examinations as a percentage of the total outage dose estimate.**

OPPD Response

The radiation dose estimate for completing supplemental UT/surface examinations is 4.1 to 6.3 Rem. This dose estimate is based on the following data:

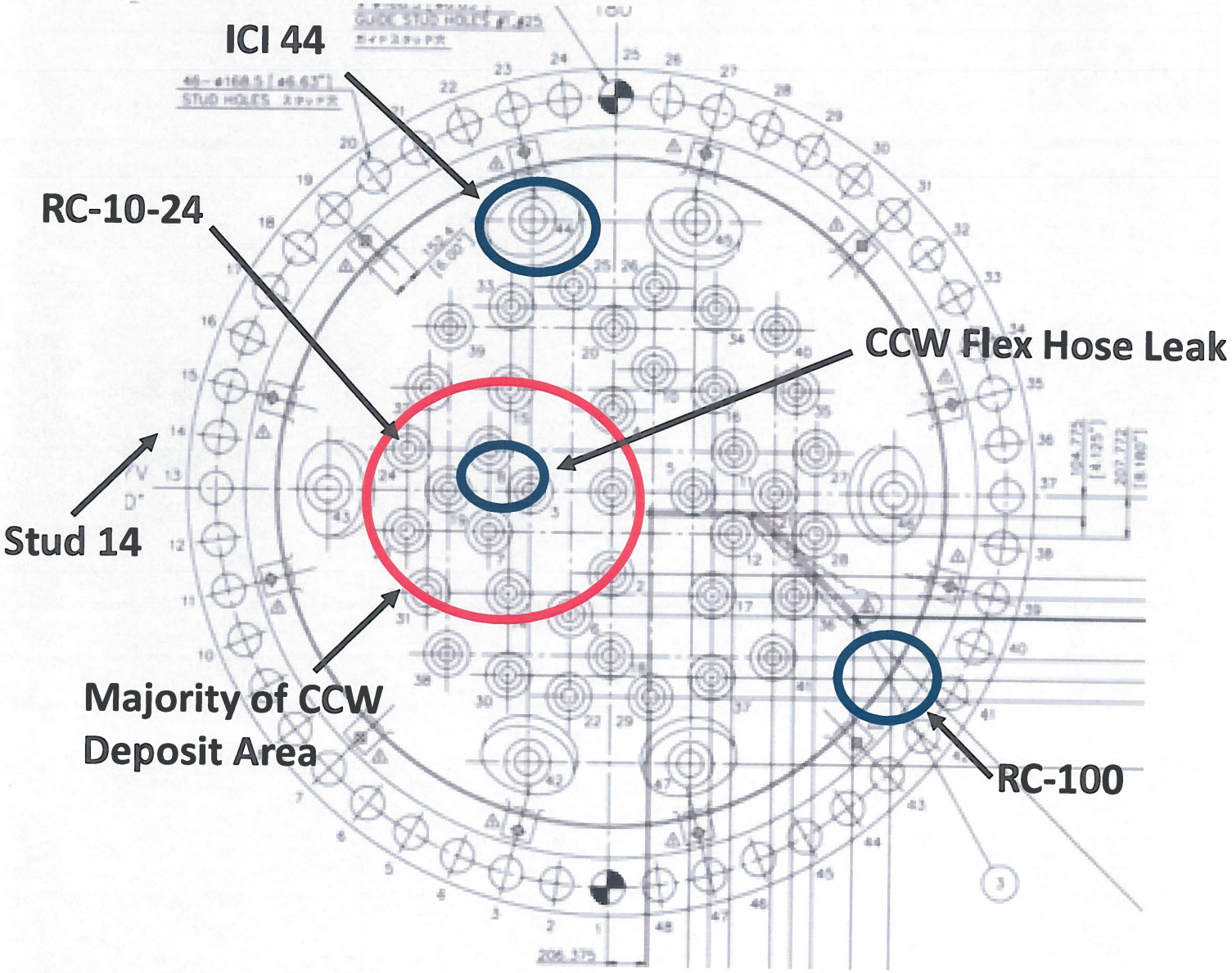
Vendor estimate for volumetric UT:	500 to 1000 mREM
Manual PT of ICI's:	735 to 990 mREM*
RV head stand and CEA modification:	2880 to 4320 mREM**
TOTAL Dose:	4115 to 6310 mREM

*15 minute/per ICI (under RV head) at 350 to 500 mREM/hour plus 30 minute/ICI (outside RV head) at 70 to 80 mREM/hour.

** 6 people for 48 hours at 10 to 15 mREM/hour. (Modification required to the RV head stand, radiation shield wall, and 4 "double" CEA configurations for UT equipment to perform inspection.)

The current dose estimate for the refueling outage is 67 REM. The 6.3 REM estimate represents 9.4% of the total dose estimate for the refueling outage.

As Left Condition of Individual Penetrations


ICI 44
RC-10-24
CCW Flex Hose Leak
Stud 14
Majority of CCW
Deposit Area
RC-100

CEDM Nozzle 1	
View – 000	View – 090
• Picture is somewhat blurred • Fillet of annulus is difficult to discern but no build-up or reduction in material is evident • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 2	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 3	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor paint was observed on head near penetration	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the bottom of the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the bottom of the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 4	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 5	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 6	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus due to water residue • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus and on the CEDM nozzle. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Staining identified on the CEDM nozzle and within the annulus. • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 7	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No Staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination; indication of one piece of lint in the annulus region in the photo

CEDM Nozzle 8	
View – 045	View – 135
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining within the annulus • No debris visible in the annulus to obstruct successful visual examination • Reflection is visible on the right-hand side of the photo	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination • Minor surface irregularity visible on surface of CEDM housing
View – 180	View – 315
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining at the bottom of the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining on the left side of the annulus • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 10 -	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination.	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

CEDM Nozzle 11 -	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus • Picture is somewhat blurred	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • Picture is somewhat blurred

CEDM Nozzle 12 -	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus •	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • Minor staining within the annulus •
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

CEDM Nozzle 14	
View – 045	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 225	View – 315
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 15	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 16 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • No staining identified in the annulus.	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • No staining identified in the annulus.
View – 90-270	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • No staining identified in the annulus.	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • No staining identified in the annulus.

CEDM Nozzle 17 -	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

CEDM Nozzle 18	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining visible in the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination.

CEDM Nozzle 19	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Piece of lint visible in the picture was removed with air following the photo inspection	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 135	View – 180
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Minor staining in a ring around the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 20	
View – 045	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 315
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 21	
View – 165	View – 235
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No observable staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No observable staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 270	View – 300
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No observable staining within the annulus • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 22	
View – 000	Description – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in metal • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus

CEDM Nozzle 23	
View – 000	View – 080
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 100	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 24	
View – 090	View – 110
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 205	View – 300
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 25	
View – 135	View –180
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 270	View – 335
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 26	
View – 045	View – 90
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus on the down-slope side • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 335
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus. • No debris visible in the annulus to obstruct successful visual examination

CEDM Nozzle 27	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Photo is somewhat blurred • Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 28	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 29	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 30	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material. • No indication of wastage or surface erosion. • Minor staining within the annulus. • No debris is visible within the annulus.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris is visible within the annulus.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining visible within the annulus • No debris is visible within the annulus.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris is visible within the annulus.

CEDM Nozzle 31	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • No staining visible in annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 32	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No visible staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be hardened CCW deposits is present in the annulus. CEDM Nozzle 32 is in the CCW leakage flowpath, this debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 33	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • Very small quantity of apparent debris found to be lint or paint flecks, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam

CEDM Nozzle 34 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus • A small amount of liquid water was present in the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus

CEDM Nozzle 35 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • No staining identified in the annulus.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • No staining identified in the annulus.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • A small amount of liquid water was present in the annulus

CEDM Nozzle 36 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam • Minor staining within the annulus

CEDM Nozzle 37	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining identified in the annulus. • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 38	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining at the top of the photo of the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining at the bottom of the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 39	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • No debris visible in the annulus to obstruct successful visual examination	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

CEDM Nozzle 40 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

CEDM Nozzle 41	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination.

ICI Nozzle 42 -	
View – 000	View – 090
• Fillet of the annulus is mostly smooth with no apparent reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • Signs of CCW deposits collected due to water pooling in the bottom of the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

ICI Nozzle 43 -	
View – 090	View – 180
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus • Visible line where insulation interface occurs	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • Visible line where insulation interface occurs
View – 270	View – 335
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus • Visible line where insulation interface occurs

ICI Nozzle 44 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Visible line where insulation interface occurs
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Minor staining within the annulus • No debris visible in the annulus to obstruct successful visual examination.

ICI Nozzle 45	
View – 090	View – 180
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • A small quantity of liquid water can be seen in the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • A small quantity of liquid water can be seen in the annulus • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus
View – 270	View – 335
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam. • Minor staining within the annulus

ICI Nozzle 46 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • Apparent white line around annulus was determined to be a reflection following additional inspections
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • A small quantity of liquid water can be seen in the annulus

ICI Nozzle 47 -	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus • Apparent white line around annulus was determined to be a reflection following additional inspections	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No debris visible in the annulus to obstruct successful visual examination. • Minor staining within the annulus

RC-100	
View – 000	View – 090
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • A small piece of debris is visible but away from the annulus. This debris did not preclude the ability to successfully complete the required VE exam.	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus • Very small quantity of apparent debris found to be lint, is present in the annulus. This debris did not preclude the ability to successfully complete the required VE exam.
View – 180	View – 270
• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • A small piece of debris is visible but away from the annulus. This debris did not preclude the ability to successfully complete the required VE exam..	• Fillet of the annulus is smooth with no apparent build-up or reduction in material • No indication of wastage or surface erosion • No staining identified in the annulus. • A small piece of debris is visible but away from the annulus. This debris did not preclude the ability to successfully complete the required VE exam.

Dominion Engineering, Inc.

Technical Note

Response to Request for Additional Information Question #6 Regarding Fort Calhoun Relief Request RR-14

TN-3941-00-01
Revision 1
May 2015

Dominion Engineering, Inc.

TECHNICAL NOTE

Response to Request for Additional Information Question #6 Regarding Fort Calhoun Relief Request RR-14

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RECORD OF REVISIONS

Rev.	Description	Prepared by Date	Checked by Date	Reviewed by Date	Approved by Date
0	Original Issue	K. J. Fuhr 05/12/2015	G. A. White 05/12/2015	G. A. White 05/12/2015	G. A. White 05/12/2015
1	Added discussion to crack growth time assessment of Section 3.1: • Arrhenius temperature adjustment • Calculation of critical crack length • Conservative treatment of stress intensity factor	K. J. Fuhr 05/15/2015	G. A. White 05/15/2015	G. A. White 05/15/2015	G. A. White 05/15/2015

The last revision number to reflect any changes for each section of the technical note is shown in the Table of Contents. The last revision numbers to reflect any changes for tables and figures are shown in the List of Tables and the List of Figures. Changes made in the latest revision, except for Rev. 0 and revisions which change the technical note in its entirety, are indicated by a double line in the right hand margin as shown here.

CONTENTS

List of Tables

1 INTRODUCTION

The purpose of this technical note is to provide a response to a specific request for additional information (RAI) item transmitted by the U.S. NRC to Omaha Public Power District (OPPD) regarding relief request number RR-14 [1]. This relief request proposes an alternative to the requirements of ASME Code Case N-729-1 [2] as conditioned by 10 CFR 50.55a(g)(6)(ii)(D) with regard to acceptance of visual examination results for the upper surface of the reactor vessel closure head (RVCH) for the current refueling outage at Fort Calhoun. The alternatives are proposed to be applied during the next operating cycle and will conclude in the refueling outage scheduled to begin the fall 2016.

2 RAI QUESTION NO. 6

Question #6 of the RAI transmitted by the U.S. NRC states:

> *Page 3 of the relief request states, "...There is no evidence of a flaw in any of the RVH [reactor vessel head] nozzles or partial penetration welds; therefore, performing emergent supplemental examination and/or repair/replacement of the nozzles does not result in a compensating increase in the level of quality or safety..." The NRC staff questions that there is no evidence of relevant conditions indicative of possible nozzle leakage because the NRC questions the effectiveness of the licensee's disposition of the relevant conditions. As such, the NRC staff is concerned regarding the potential for nozzle ejection or significant degradation of the low alloy steel reactor vessel head due to boric acid corrosion if the nozzles with relevant conditions are allowed to remain in service. Therefore, provide technical basis to demonstrate that nozzle ejection or a loss of upper head structural integrity will not occur during the duration of this proposed alternative. If the licensee has performed calculations to address the level of quality or safety for the proposed alternative, the NRC staff notes that the time to leakage, given the short operational lifetime of the current reactor vessel head would not provide a sufficient basis for crack growth rate improvement factors due to the use of alloy 690 or its weld materials.*

3 RESPONSE TO RAI QUESTION 6

3.1 Concern for Nozzle Ejection

The potential concern for nozzle ejection is evaluated using Table 3-1 of Electric Power Research Institute (EPRI) Materials Reliability Program report MRP-395 [3]. This table shows the results of several representative calculations for the time for growth of an initial 30° through-wall circumferential to reach a circumferential extent of 300°, which is a conservatively small measure of the critical size for nozzle ejection. These calculations are for Alloy 600 nozzles, and thus they take no credit for the factors of improvement for Alloy 690/52/152 materials observed in laboratory testing [4]. In addition, these calculation results conservatively reflect application of a factor of 2 on the PWSCC crack growth rate to account for the potential effect of chemical concentration on the nozzle OD. For a head temperature of 605°F, the lower bound time for circumferential crack growth in MRP-395 [3] is 7.4 EFPYs. Because the calculation cases in Table 3-1 of MRP-395 [3] are representative of top head nozzle geometries in the U.S. PWR fleet, the minimum calculated growth time from this table is expected to be bounding for the Fort Calhoun top head nozzle geometries.

At the head temperature for Fort Calhoun of 588°F ([5], [6]),[1] this crack growth time corresponds to 11.4 EFPYs (using the standard Arrhenius temperature dependence and the standard activation energy of 31 kcal/mole for PWSCC crack growth per ASME Code Case N-729-1 [2]). A period of 11.4 EFPYs is greater than the total operating time of 6.56 EFPY [7] for the replacement head from the time of replacement in 2006 projected until the time of the next refueling outage scheduled to begin the fall 2016 (i.e., the end of the period for the requested alternative). Thus, even without crediting any time for crack initiation and through-wall penetration and even without crediting the improved performance of Alloys 690/52/152 versus Alloys 600/82/182, nozzle ejection is shown to be precluded during the duration of the proposed alternative.

3.1.1 Adjustment of Crack Growth Time for Head Operating Temperature

For the purposes of this assessment, it is assumed that the crack growth rate for Alloy 600 material applies to the top head nozzles of the replacement head at Fort Calhoun, even though the nozzles were fabricated with Alloy 690. The deterministic crack growth times presented in

[1] Because reactor thermal power and reactor cold-leg temperature are nominally the same for the replacement head as for the original head in 2001, the MRP-48 [5] operating head temperature value of 588°F still applies to the replacement head [6].

Table 3-1 of MRP-395 [3] were calculated using the standard PWSCC crack growth rate equation for thick-wall Alloy 600 material presented in MRP-55 [12] and Paragraph C-8511 of Nonmandatory Appendix C of ASME Section XI [13]. The temperature sensitivity for this standard crack growth rate equation is given by the standard Arrhenius relation with a thermal activation energy of 31 kcal/mole ([12], [13]):

$$f_{temp} = \exp\left[-\frac{Q_g}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right] \quad [3\text{-}1]$$

where:

f_{temp} = temperature adjustment factor
Q_g = thermal activation energy for crack growth (31 kcal/mole)
R = universal gas constant (1.103×10^{-3} kcal/mole-°R)
T = absolute operating temperature at location of crack, °R
= operating head temperature = (588 + 459.67) °R = 1047.67 °R
T_{ref} = absolute reference temperature used to normalize data, °R
= (605 + 459.67) °R = 1064.67°R for the bounding 7.4 EFPY growth time value in Table 3-1 of MRP-395 [3]

The temperature factor is calculated as follows:

$$f_{temp} = \exp\left[-\frac{31}{1.103\times10^{-3}}\left(\frac{1}{1047.67}-\frac{1}{1064.67}\right)\right] = 0.6516 \quad [3\text{-}2]$$

Thus, the crack growth rate at 588°F is a factor of 0.6516 times the crack growth rate at 605°F. The crack growth time at 588°F is 7.4 / 0.6516 = 11.4 EFPYs.

3.1.2 Calculation of Critical Crack Length for Fort Calhoun Replacement Head CEDM and ICI Nozzles

Critical crack lengths for through-wall circumferential flaws located above the top of the weld in Alloy 600 CRDM, CEDM, and ICI nozzles in U.S. PWRs were presented in Appendix D of MRP-110 [8]. This same methodology applies to determine the critical sizes for the CEDM and ICI nozzles of the replacement head at Fort Calhoun.

The tight fit of the nozzle in the vessel head will ensure that moment loads on the nozzle are low and that the limit load will be equal to the material flow stress acting on the remaining ligament. The calculation of the critical flaw size presented below is based on the design pressure. In the calculation below, it is assumed that the pressure load is applied to the crack face as well as the nozzle bore diameter:

$$P_{lim} = \sigma_f \left[\frac{A_{wall}\left(1 - \frac{\theta}{360}\right)}{A_{bore} + A_{wall}\left(\frac{\theta}{360}\right)} \right] \quad [3\text{-}3]$$

where:

P_{lim} = limit pressure = design pressure
σ_f = tensile flow stress = $0.5(\sigma_y + \sigma_u)$
σ_y = yield strength at the design temperature (ksi)
σ_u = tensile strength at the design temperature (ksi)

Solving for the crack angle θ that produces the limit pressure,

$$\theta = \frac{360\left[\sigma_f - P_{lim}\left(\frac{A_{bore}}{A_{wall}}\right)\right]}{P_{lim} + \sigma_f} \quad [3\text{-}4]$$

where:

θ = circumferential crack extent (degrees)
A_{bore} = nozzle bore area = $\pi D_i^2/4$
A_{wall} = nozzle wall area = $\pi (D_o^2 - D_i^2)/4$

As noted above, because of the tight fitting annulus and of the high ductility of the nozzle materials, bending loads on the nozzle at the top of the vessel head, including seismic moments, will not affect the required minimum ligament. Therefore, the required ligament is that which will withstand the design pressure acting on the nozzle bore and the crack face at flow stress levels in the ligament. For large crack sizes, the stress level may be calculated as the pressure force over the combined bore and crack face areas divided by the cross-sectional area of the ligament. For smaller size cracks, the maximum permissible pressure is limited by the burst pressure in cracked tubes rather than axial stress in the remaining ligament. The evaluation presented here is restricted to the methodology for large circumferential cracks because it is the axial stress in the ligament that controls the limiting crack size at the design pressure.

The required inputs are the inside and outside nozzle diameters for the region immediately above the J-groove weld [14], the nozzle material minimum flow strength, and the design pressure (standard PWR value of 2500 psi assumed). The values of σ_y and σ_u for Alloy 690 nozzle material procured to ASME specifications SB-166 and SB-167 (annealed condition) at the standard design temperature of 650°F are given in Section II of the ASME Boiler & Pressure Vessel Code [15]. As noted in the equations above and according to standard practice, the

minimum nozzle flow strength is taken as the average of the minimum yield and ultimate tensile strengths.

The calculation inputs and results for the replacement Fort Calhoun head are shown in Table 1. The calculated critical circumferential crack extent for the ICI nozzle is 327° and for the CEDM nozzle is 326°. These values conservatively exceed the 300° circumferential extent assumed in the deterministic crack growth calculations cited in Table 3-1 of MRP-395 [3].

Table 1 Calculation of Critical Crack Lengths for Fort Calhoun Replacement Head Nozzles

Nozzle Type	*ID* (in.)	*OD* (in.)	t (in.)	Bore Area A_{bore} (in^2)	Wall Area A_{wall} (in^2)	Yield Strength S_y (ksi)	Tensile Strength S_u (ksi)	Flow Strength S_f (ksi)	Limit Load Pressure P_{lim} (psi)	Limit Flaw Angle θ (deg)
ICI	5.189	7.189	1.000	21.1474	19.4433	27.5	80.0	53.75	2,500	327
CEDM	2.728	3.728	0.500	5.8449	5.0705	27.5	80.0	53.75	2,500	326

3.1.3 Conservative Treatment of Stress Intensity Factor

The approach taken in MRP-395 [3] was to compile existing calculation results for a wide range of top head Alloy 600 nozzle cases for the purpose of comparing the time for growth to a critical crack size with the inspection intervals required by ASME Code Case N-729-1 [2] as mandated and conditioned by 10 CFR 50.55a. Thus, Table 3-1 of MRP-395 represents the best available compilation of crack growth calculation results for the purpose of assessing the nozzle ejection concern at Fort Calhoun without taking any credit for the high PWSCC resistance of Alloy 690 material displayed in tests such as PWSCC crack growth rate testing [4].

The PWSCC crack growth rate for Alloy 600 is dependent on the crack-tip stress intensity factor and the head operating temperature. The temperature applicable to Fort Calhoun and the temperature dependence of the crack growth rate are discussed above. The crack-tip stress intensity factor for circumferential flaws in the nozzle tube is largely dependent on the weld residual stresses developed in the nozzle tube due to weld shrinkage and subsequent nozzle ovalization, with additional components due to the pressure stresses in the nozzle tube and pressure on the crack face. The different approaches to stress intensity factor calculation that have been taken for through-wall circumferential flaws in head nozzles were summarized in Section 5.3 of MRP-110 [8]. The description in MRP-110 includes several plots comparing the stress intensity factor as a function of circumferential crack extent for various analysis cases. The case in Table 3-1 of MRP-395 with the bounding crack growth time (i.e., 7.4 EFPYs at

605°F) assumed the bounding high stress intensity factor dependence on crack extent presented in Section 5.3 of MRP-110 (i.e., the MRP-105 [16] Plant C case for a downhill centered crack). This assumed stress intensity factor dependence was calculated assuming that stress intensity factor superposition is valid. However, as shown through comparison with FEA cases explicitly modeling the redistribution of stresses in the presence of a large through-wall circumferential flaw [8], the superposition method results in overly conservative stress intensity factor results. The reason is that a large circumferential flaw produces a substantial change in the global compliance of the nozzle and breakdown of the superposition effect when modeling the effect of localized residual stresses.

Hence, the stress intensity factor assumption applied in this assessment results in a highly conservative crack growth rate time. Moreover, as mentioned above, a multiplicative factor of 2 increasing the PWSCC crack growth rate for Alloy 600 was conservatively applied to account for the uncertainty in the chemical environment that exists in the nozzle OD annulus for a leaking penetration.

3.2 Concern for Boric Acid Corrosion of Low-Alloy Steel

The potential concern for boric acid corrosion due to leakage through the penetration nozzle tube and/or attachment weld is evaluated on the basis of the extensive mockup testing and analyses documented in a series of EPRI MRP reports. These reports include MRP-110 [8], MRP-117 [9], MRP-308 [10], MRP-375 [11], and MRP-395 [3]. This work demonstrates that more than a single fuel cycle of operation (i.e., more than 24 months of operation) is necessary to produce structurally significant corrosion of the low-alloy steel head given a leaking Alloy 600 nozzle. These assessments do not credit the crack growth rate factors of improvement for Alloy 690/52/152 materials observed in laboratory testing [4]. The visual examinations performed during the current refueling outage revealed no discernible wall loss of the low-alloy steel head material ([1], [7]). Thus, assuming that a nozzle was leaking prior to the current refueling outage, the potential boric acid corrosion effects of such leakage would be in its earliest stages. Thus, even without crediting the improved performance of Alloys 690/52/152 versus Alloys 600/82/182, a loss of upper head structural integrity is shown to be precluded during the duration of the proposed alternative.

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