

# WOLF CREEK

NUCLEAR OPERATING CORPORATION

Jaime H. McCoy  
Vice President Engineering

October 14, 2016  
ET 16-0027

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

- Reference : 1) Letter ET 16-0005, from J. H. McCoy, WCNOC, to USNRC dated February 23, 2016, Wolf Creek Generating Station Inservice Inspection Plan and 10 CFR 50.55a Requests I4R-01 and I4R-02 for the Fourth Inservice Inspection Program Interval.
- 2) Letter WO 16-0052, from C. O. Reasoner, WCNOC, to USNRC dated October 11, 2016, Wolf Creek Generating Station Docket No. 50-482: Relief Request Number I4R-03, Request for Relief from Paragraph-3200(b) of ASME Code Case N-729-1 for Reactor Vessel Head Penetration Nozzle Welds and Relief Request I4R-04, Request for Relief from the Requirements of ASME Code Case N-729-1.

Subject: Docket No. 50-482: Relief Request Number I4R-03, Request for Relief from Paragraph-3200(b) of ASME Code Case N-729-1 for Reactor Vessel Head Penetration Nozzle Welds and Relief Request I4R-04, Request for Relief from the Requirements of ASME Code Case N-729-1

Gentlemen:

During the current Refueling Outage (RF)21, the reactor vessel closure head (RCVH) penetration nozzles were examined in accordance with Code Case N-729-1 and both Wolf Creek Generating Station (WCGS) Inservice Inspection (ISI) and Boric Acid Programs. A canopy seal weld leak led to the shutdown of the plant into RF21.

The canopy seal weld leak from nozzle 77 was uncharacteristically large compared to canopy seal weld leaks typically experienced within the industry, approximately 0.5 gpm. This led to undesirable buildup of boric acid residue on nearby components. Substantial resources and time have been added to the RF21 work scope due to the inspection and cleanup required for determining that the head pressure boundary and control rod function will perform as designed.

Specifically, the resulting boric acid accumulation from the canopy seal weld leak covered a portion of the head which is the focal point of the head inspection. The boric acid accumulation obscured adequate visual inspection of 12 reactor head vessel nozzles. Wolf Creek Nuclear Operating Corporation (WCNOC) is confident that the observed boron accumulation was the

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result of the canopy seal weld leak. Twelve head to nozzle interface areas were obscured such that adequate visual examination is not possible on the top side of the reactor head. Because of this, WCNOG will be performing a supplemental volumetric examination of those nozzles from the underside of the head in accordance with Code Case N-729-1. This code case also requires a surface examination of the partial penetration welds from the bottom side of the reactor head. WCNOG is requesting relief from that requirement due to hardship without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(z)(2), WCNOG hereby requests Nuclear Regulatory Commission (NRC) approval of 10 CFR 50.55a Request Number I4R-03 for the WCGS ISI Program, fourth ten-year interval. Attachment 1 identifies the affected components, applicable American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME) Code requirements, reason for request, proposed alternative, and basis for proposed alternative. The alternative proposed is to be applied during RF21, which is in Interval Four (September 3, 2015 - September 2, 2025).

WCNOG will return to the normal inspection protocol for the remainder of ISI Interval Four, which began September 3, 2015 and ends on September 2, 2025 (Reference 1). WCNOG requests approval of this request by October 17, 2016, to support restart from RF21.

This submittal replaces Reference 2 in its entirety.

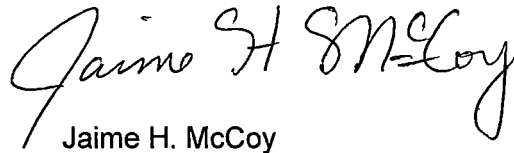
In addition, pursuant to 10 CFR 50.55a(z)(2), WCNOG hereby requests NRC approval of 10 CFR 50.55a Request Number I4R-04 for the Fourth Ten-Year Interval of WCNOG's Inservice Inspection (ISI) Program. The attached 10 CFR 50.55a Request (I4R-04) requests relief from certain ASME Code Case N-729-1 requirements for examination of reactor vessel head partial penetration welds. (Attachment 2) This request is similar to that requested in the Third Ten Year Interval of WCNOG's ISI that was accepted by ML 12353A241.

The Code of Federal Regulations 10 CFR 50.55a(g)(6)(ii)(D)(1) requires that examinations of the RCVH be performed in accordance with ASME Code Case N-729-1 subject to conditions specified in paragraphs 10 CFR 50.55a(g)(6)(ii)(D)(2) through (6). The vendor chosen by WCNOG to perform these examinations is unable to meet required examination coverage below the J-groove weld on two control rod drive mechanism (CRDM) penetrations. Both of these CRDM penetrations are configured such that the volumetric examination distance required by N-729-1 cannot be met. Attachment 2 to this letter, 10 CFR 50.55a Request I4R-04, documents the ultrasonic coverage limitations.

WCNOG had intended to request this relief prior to planned inspections in RF23 but the circumstances described above have required that the examination of one of the subject penetrations be performed at this time during current RF21. Therefore, WCNOG requests approval of the attached 10 CFR 50.55a Request I4R-04 by October 17, 2016, to support inspection and restart from RF21, which is now scheduled to complete November 18, 2016.

This letter contains no commitments. If you have any questions concerning this matter, please contact me at (620) 364-4156, or Cynthia R. Hafenstine (620) 364-4204.

Sincerely,



Jaime H. McCoy

JHM/rlt

Attachments: 1) 10 CFR 50.55a Request Number I4R-03  
2) 10 CFR 50.55a Request Number I4R-04

cc: K. M. Kennedy (NRC), w/a  
B. K. Singal (NRC), w/a  
N. H. Taylor (NRC), w/a  
S. P. Lingam (NRC), w/a  
Senior Resident Inspector (NRC), w/a

**Wolf Creek Nuclear Operating Corporation  
10 CFR 50.55a Request I4R-03**

**Relief Requested In Accordance with  
10 CFR 50.55a(z)(2)**

**10 CFR 50.55a Request Number I4R-03**

**Relief Requested  
In Accordance with 10 CFR 50.55a(z)(2)**

**Proposed Alternative in Accordance with 10 CFR 50.55a(z)(2)  
Hardship or Unusual Difficulty Without Compensating  
Increase in Level of Quality or Safety**

• ASME Code Component(s) Affected

Component:	Reactor Vessel Closure Head (RVCH) Nozzles
Code Class:	Class 1
Examination Category:	B-P
Code Item Number:	B4.10 (Code Case N-729-1, Alternative Examination Requirements for PWR Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1)
Description:	Control Rod Drive Mechanism (CRDM) Nozzles Core Exit Thermocouple Nozzle Assy (CETNA) Nozzles  12 Penetration Nozzles – Numbers 20, 27, 35, 40, 46, 47, 58, 59, 63, 70, 71, and 77
Size:	4.00 Inch (Nominal Outside Diameter)
Material:	RVCH SA533 Grade B, Class 1 Nozzle SB 167 N06600 (Alloy 600) Alloy 82/182 weld material

2. Applicable code Edition and Addenda

- American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, 2007 Edition through 2008 Addenda
- Code Case N-729-1 as conditioned by 10 CFR 50.55a(g)(6)(ii)(D)

3. Applicable Code Requirement

10 CFR 50.55a(g)(6)(ii)(D)(1) requires that examinations of the reactor vessel head be performed in accordance with ASME Code Case N-729-1 subject to the conditions specified in paragraphs 10 CFR 50.55a(g)(6)(ii)(D)(2) through (6).

Paragraph -3200(b) of code Case N-729-1 states:

*The supplemental examination performed to satisfy -3142.2 shall include volumetric examination of the nozzle tube and **surface examination of the partial-penetration weld**, (emphasis added) or surface examination of the nozzle tube inside surface, the partial penetration weld, and nozzle tube outside surface below the weld, in accordance with Fig. 2, or the alternative examination area or volume shall be analyzed to be acceptable in accordance with Appendix I. The supplemental examinations shall be used to determine the extent of the unacceptable conditions and the need for corrective measures, analytical evaluation, or repair / replacement activity.*

4. Reason for Request

Based on visual examination (VE), deposits resulting from leakage in the canopy seal weld on penetration 77 are on the RVCH. These deposits are dispersed on the reactor head in such a way that it is evident they resulted from the spray pattern, or spray deflection, from the canopy seal weld leak. Other observations noted were: 1) the condition of the head which only had surface rust present rather than wastage; 2) the color and location of these deposits were consistent with spray following the crud burst that was then oxidized by exposure to the atmosphere; 3) there was a layer of white boric acid on top of the deposits in a similar pattern indicating that clean borated water had followed the same path; and 4) no penetrations other than those in the path of the spray/deflection show any abnormal indications.

Wolf Creek Nuclear Operating Corporation (WCNOC) has volumetrically examined the RVCH previously in 2006 and 2013. There was no degradation identified in either of these examinations. Results from the exam performed in RF21 will be compared to the data from the previous two exams for any changes in leak path data, thus providing further assurance of no new leak path.

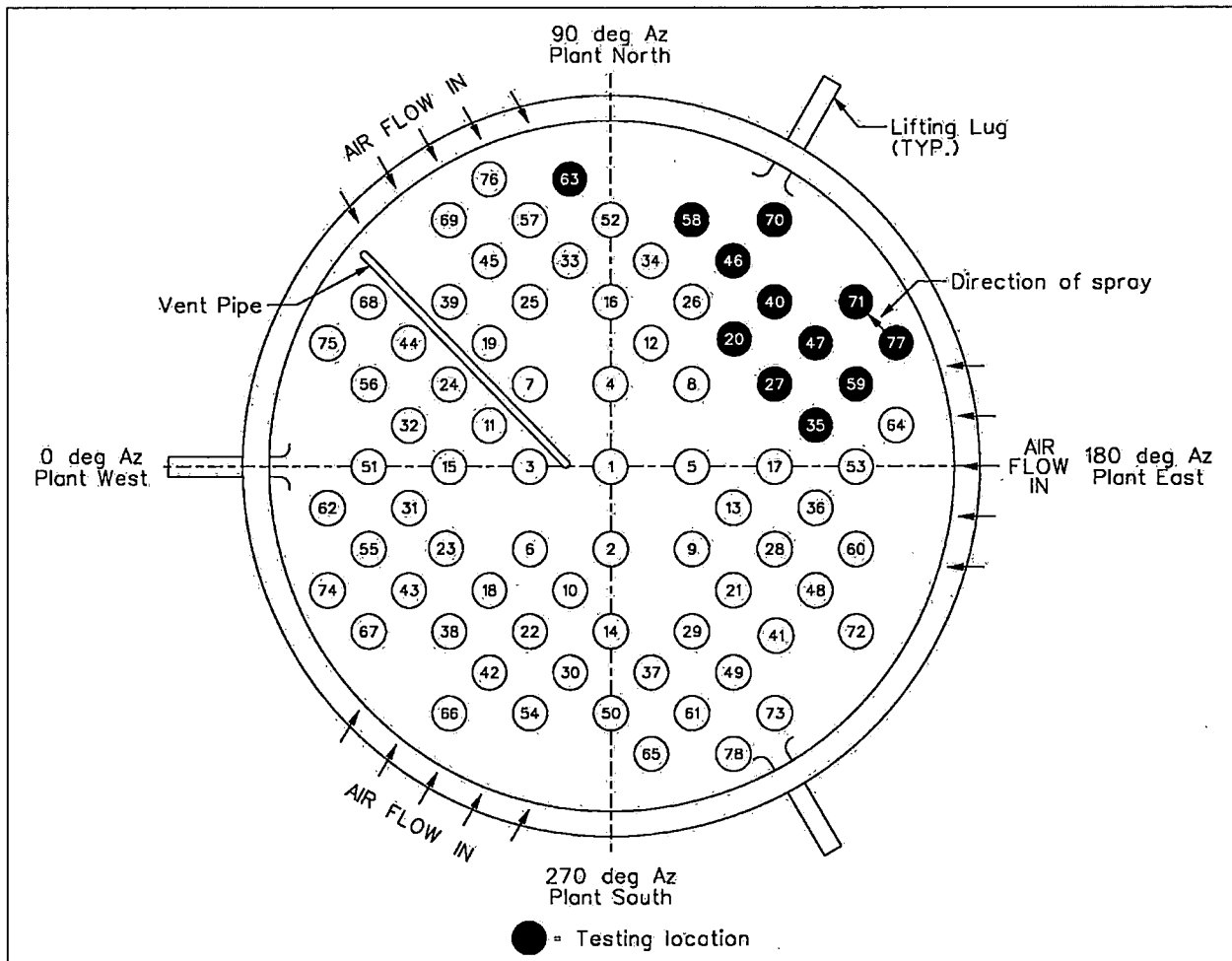


Figure 1

Based on VE deposits resulting from leakage in the canopy seal weld area above the closure head surface on penetration 77 were found on the RCVH. These deposits were found in locations consistent with leakage from the canopy seal weld traveling down onto the RVCH and penetration nozzles. WCNOG will perform supplemental volumetric examinations of the obscured penetrations.

Twelve penetrations require supplemental volumetric examination in accordance with code case N-729-1. Per paragraph -3200(b) of N-729-1 these supplemental examinations "...shall include volumetric examination of the nozzle tube and **surface examination of the partial-penetration weld,...**".

WCNOG does not have the internal resources to conduct the volumetric and surface examinations as required by Code Case N-729-1 – 3200(b). A third party vendor has been contracted to perform the volume examination. The options for the surface examination of the partial penetration weld are: 1) the dye penetrant technique or 2) the eddy current technique. The dye penetrant technique carries an estimated dose of approximately 1500 mRem (1.5 REM) per nozzle, which would result in approximately 18 REM to perform the partial weld surface examination. The equipment that could be used to perform the eddy current technique has not been recently calibrated and examined; and there are few qualified personnel to use the equipment available to support the WCNOG refueling outage.

The volumetric examination of the nozzle tube will be performed with remotely operated tooling that is mounted on a manually positioned tool stand. In order to perform the supplemental volumetric examination of 12 penetrations, 13 entries under the RV closure head are required. The first entry is estimated to take approximately 10 minutes accumulating 408 mRem of exposure. The remaining entries are estimated to take approximately 2 minutes each yielding 81 mRem of exposure or 972 mRem for a total of 1380 mRem for under-head entries. An additional 320 mRem will be accumulated during equipment set up and calibration activities that take place in the vicinity of the RVCH for a total of 1700 mRem. In order to perform the surface examination of the partial penetration weld using the Eddy Current technique, an additional 13 entries under the RV closure head would be required, resulting in a projection of two times the dose accumulated for the leak path assessment and volumetric exam alone or ~3.4 Rem to include the eddy current surface exam.

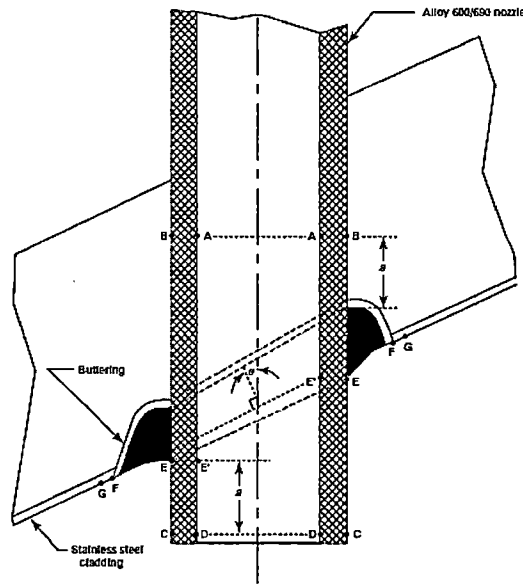
The vendor has estimated the time required to perform the volumetric examinations as 7 days (3 days of equipment set up, 2 days to perform examinations [12 nozzles at 6 nozzles per day], and 2 days of equipment teardown). In order to perform the surface examination of the partial penetration weld with Eddy Current, an additional 10 days would be required, 3 days for equipment set up, 6 days to perform examinations, and 1 day to demobilize, as the process can only complete 2 examinations per 12 hour shift - there are only enough qualified personnel to cover one shift.

Based on original outage schedule projections, the additional scope for eddy current testing of the partial penetration weld surfaces would extend the timeline of RF21 by 10 days.

##### 5. Proposed Alternative and Basis for Use

WCNOG proposes to perform a demonstrated volumetric leak path assessment (in addition to the volumetric examination) in lieu of the surface examination of the partial penetration weld. The leak path assessment can be performed in tandem with the nozzle tube

volumetric exams and will not add any additional dose. This combination (volumetric examination of the nozzle tube and volumetric leak path assessment) will provide confirmation that all of the deposits observed on the RV closure head were a result of the canopy seal weld leak. WCNOC believes the combination of volumetric exams and leak path assessment will provide an acceptable level of assurance in the condition of each penetration. This is because, as shown in the figure below, the two examinations will verify there are no indications in the nozzle tube and verify there has been no leakage in the penetration tube to RVCH interface.



The volumetric exam is the area from points A-B-C-D. The leak path assessment will cover the interface between the nozzle and the carbon steel head to at least 2" above the J-groove weld. Performing the leak path assessment in lieu of the surface examination of the J-groove weld will demonstrate that the boric acid deposits observed on the exterior of the head were a result of the canopy seal weld leak.

WCNOC will conduct the volumetric and leak path assessments. The table below lists the type of probe used and the distance above the weld measured in 2013 using the axially shooting TOFD transducer. All of the 0° UT data axial coverage was at least 2 inches above the top of the J-groove weld.



Penetration No.	$\theta$ (degrees)	Exam Probe	2013 Coverage Obtained Above Weld (Axial Shooting) in inches
20	24.8	Combo-2	3.22
27	26.2	OHS	3.64
35	30.3	Combo-2	3.00
40	34.0	Combo-2	3.44
46	35.2	Combo-2	3.04
47	35.2	Combo-2	2.76
58	38.7	Combo-2	2.80
59	38.7	Combo-2	3.12
63	44.3	Combo-2	2.60
70	45.9	Combo-2	2.96
71	45.9	Combo-2	3.20
77	48.7	OHS	3.32

The probes used in the 2013 exams are as given below:

The Open Housing Scanner (OHS) uses Type PSC-24 TOFD 5 MHz transducers with a refracted angle of 55° for the circumferential shooting and a refracted angle of 40° for the axial shooting.

The Combo-2 blade probes use a Type PCS-20.5 TOFD 6.2 MHz transducer with a refracted angle of 57° for the circumferential shooting and a Type PSC-23.5 TOFD 6.2 MHz transducers with a refracted angle of 44° for the axial shooting.

In both the OHS and Combo-2 probes, the search units utilized for the 0° longitudinal wave examination have a nominal frequency of 2.25 MHz.

The exams to be performed in RF21 will use the same probes, that will be set up with the same transducers.

WCNOC has examined the RVCH previously in 2006 and 2013 - degradation was not identified in either of these examinations. Results from the exam performed in RF21 will be compared to the data from the previous two exams for any changes in leak path data, thus providing further assurance of no new leak path.

WCNOC will clean the RVCH and perform a supplemental VE of the twelve penetrations prior to the returning the RVCH to service in Refueling Outage 21 and also in Refuel 22 to confirm that there continues to be no indication of leakage through these penetrations. Following these exams WCNOC will return, in Refueling Outage 23, to the normal inspection process required by N-729-1, as conditioned by 10 CFR 50.55a, for the duration of the Fourth ISI Interval.

WCNOC believes that the estimated additional dose, the added time, and significant cost associated with the surface examination of the partial penetration welds will not provide any additional benefit over the proposed Leak Path Assessment and Volumetric examination.

Therefore performing surface examination of the partial penetration welds is a hardship that does not result in a compensating increase in the level of quality or safety.

If an unacceptable indication by the leak path assessment or volumetric exam is identified, WCNOG will revert to the requirements of Code Case N-729-1 and 10 CFR 55a(g)(6)(ii)(D).

6. Duration of Proposed Alternative

The proposed alternative will be utilized only during WCNOG RF21. WCNOG will return to the normal inspection protocol for the remainder of ISI Interval Four, which began September 3, 2015 and ends on September 2, 2025.

7. Precedent

None

8. References

1. ASME Boiler and Pressure Vessel Code Case N-729-1 "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds Section XI, Division 1"
2. NUREG CR 7142, "Ultrasonic Phased Array Assessment of the Interference Fit and Leak Path of the North Anna Unit 2 Control Rod Drive Mechanism Nozzle 63 with Destructive Validation"
3. WDI-T J-0-03-P, "Ultrasonic Testing of Interference Fit Samples for Leak Path Detection (PWROG PA-MS-0532)"

**Wolf Creek Nuclear Operating Corporation**  
**10 CFR 50.55a Request I4R-04**  
**Relief Requested from the Requirements**  
**of ASME Code Case N-729-1**

**10 CFR 50.55a Request I4R-04**

**Relief Requested from the Requirements of ASME  
Code Case N-729-1**

**Proposed Alternative in Accordance with 10 CFR 50.55a(z)(2)  
Hardship or Unusual Difficulty Without Compensating  
Increase in Level of Quality or Safety**

**1. ASME Code Components Affected**

Code Class:	1
Reference:	ASME Code Case N-729-1 / 10 CFR 50.55a(g)(6)(ii)(D)
Item No.:	B4.20
Description:	UNS N06600 Nozzles and UNS N06082 or UNS W86182 Partial-Penetration Welds in Head. Reactor vessel head control rod drive mechanism (CRDM) penetration nozzle base material and J-groove weld that attaches the nozzle base material to the underside of the head for penetration nozzles 77 and 78.

**2. Applicable Code Edition and Addenda**

ASME Code Section XI, 2007 Edition through 2008 Addenda, as augmented by ASME Code Case N-729-1 (Reference 1), "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds Section XI, Division 1," as amended by 10 CFR 50.55a(g)(6)(ii)(D).

**3. Applicable Code Requirement**

10 CFR 50.55a(g)(6)(ii)(D)(1) requires that examinations of the reactor vessel head be performed in accordance with ASME Code Case N-729-1 subject to the conditions specified in paragraphs 10 CFR 50.55a(g)(6)(ii)(D)(2) through (6).

Paragraph -2500 of Code Case N-729-1 states, in part:

If obstructions or limitations prevent examination of the volume or surface required by Figure 2 for one or more nozzles, the analysis procedure of Appendix I shall be used to demonstrate the adequacy of the examination volume or surface for each such nozzle. If Appendix I is used, the evaluation shall be submitted to the regulatory authority having jurisdiction at the plant site.

Figure 2 in ASME Code Case N-729-1, as referenced by paragraph -2500, requires that the volumetric or surface examination coverage distance below the toe of the J-groove

weld (i.e. dimension "a") be 1.5 inches for incidence angle,  $\theta$ , less than or equal to 30 degrees; 1 inch for incidence angle,  $\theta$ , greater than 30 degrees; or to the end of the tube, whichever is less. These coverage requirements are applicable to Wolf Creek Generating Station (WCGS) RVCH penetrations as shown in Table 1.

**Table 1: WCGS Reactor Vessel Head Penetration Coverage Requirements**

<b>Penetration Numbers</b>	<b>Incidence Angle, <math>\theta</math> (degrees)</b>	<b>Required Coverage, "a" (inches)</b>
1 to 29	$\leq 30$	1.5
30 to 78	$> 30$	1.0

**4. Reason for Request**

Due to physical configuration of certain RVCH penetration nozzles, full examination volume required by ASME Code Case N-729-1 Table 1 cannot be achieved for RVCH penetration nozzles 77 and 78, therefore, use of Mandatory Appendix I is requested in accordance with 10 CFR 50.55a(g)(6)(ii)(D)(6).

RVCH CRDM penetrations at WCGS have two styles of ends, referred to as Type "X" and Type "Y" (Figure 1). Penetrations 1 through 73 are Type "Y" that are essentially a smooth wall cylinder with a radius at the outer diameter and inner diameter. Penetrations 74 through 78 have a threaded outside diameter and an internal taper.

The design of RVCH penetration nozzles 74 through 78, referred to as Type "X", (Figure 1) includes a threaded section, approximately 1.19 inch in length at the bottom of the nozzles. These penetrations are located at the 48.7 degree location. The dimensional configuration at this location is such that the distance from the lowest point at the toe of the J-groove weld to the top of the threaded region could be less than the required coverage dimension "a" shown in Figure 2 of ASME Code Case N-729-1. Therefore, deviation from the required inspection coverage is sought for RVCH penetrations 77 and 78, as the required coverage for these two penetrations cannot be obtained.

The table below lists the coverage obtained on nozzles 74-76 during the 2006 and 2013 exams performed per NRC Order EA-03-009 (2006) and N-729-1 (2013).

Note: The lower measurement in 2006 was performed using circumferential shooting TOFD transducers while the 2013 measurements were accomplished using axial shooting TOFD transducers. While the table below shows different coverage values it is noted in the 2013 exam report that the "Lower extent comparison using Channel 2 data shows no change from 2006 to 2013 measurements."

Penetration No.	$\theta$ (degrees)	N-729-1 Required Exam Coverage (inches)	2006 Inspection Coverage Obtained (inches)	2013 Inspection Coverage Obtained (inches)
74	48.7	1.0	1.04	1.00
75	48.7	1.0	1.08	1.08
76	48.7	1.0	1.12	1.00

The physical process of welding results in slightly different weld sizes/contours being applied to each component. (This was a manual welding process, and it is not physically possible for a human to apply the exact same amount of weld metal to each component.) This is acceptable as long as the minimum design weld size or contour is met. When access is limited (as the case on the downhill side of the peripheral penetrations), this condition is magnified. This is the case in penetrations 77 and 78, as more weld metal was applied to the downhill portion of the weld, resulting in less of the penetration (below the toe of the weld and above the threads) being available for examination.

For the initial examinations of RVCH penetration welds performed in accordance with Reference 6, a similar request was previously submitted for inability to examine the required examination volume (References 3 and 4). This previous request was approved by the NRC in Reference 5. For the examinations performed in 2013 in accordance with Reference 1, as conditioned by 10 CFR 50.55a, another similar request was submitted and approved (references 7, 8, & 9).

## 5. Proposed Alternative and Basis for Use

As an alternative to the volumetric and surface examination coverage requirements shown as dimension "a" in Figure 2 of ASME Code Case N-729-1, WCGS proposes to examine at least 0.5" below the toe of the lowest point of the J-groove weld. The required examination coverage dimension for the other penetrations will be met or exceeded. The use of 0.5" will allow for improvements/changes in the vendor equipment that could lead to a more conservative measurement in the distance from the toe of the weld to the threaded area

Table 2 shows the attainable coverage achieved in 2006 and in 2013.

**Table 2: WCGS Inspection Coverage Obtained for CRDM Penetrations Having Limited Coverage**

Penetration No.	$\theta$ (degrees)	N-729-1 Required Exam Coverage (inches)	Inspection Coverage Measurement Circumferential scan (inches)	Inspection Coverage Measurement Axial scan (inches)
77	48.7	1.0	0.6	0.6
78	48.7	1.0	0.88	0.64

Note: The lower measurement in 2006 was performed using circumferential shooting TOFD transducers while the 2013 measurements were accomplished using axial shooting TOFD transducers. There is no change in coverage when comparing the Channel 2 data (which records the data from the circumferential shooting TOFD transducer) between the 2006 and 2013 exams. Both examination directions (circumferential and axial) obtain coverage to the center of the thread relief area (see figure 4). For penetration 77, the data obtained from axial shooting transducer shows the distance from the bottom of the J-groove weld to the center of the thread relief to be 0.6", with the data from the circumferential shooting transducer indicating the same distance. For penetration 78, the data obtained from the circumferential shooting transducer shows the distance from the bottom of the J-groove weld to the center of the thread relief to be 0.88", with the data from the axial shooting transducer indicating the distance to be 0.64".

Appendix I of ASME Code Case N-729-1 provides the analysis procedure for evaluation of an alternative examination area or volume to that specified in Figure 2 of Code Case N-729-1 if impediments prevent examination of the complete zone. Section I-1000 of ASME Code Case N-729-1 requires, for alternative examination zones below the J-groove weld, that analyses shall be performed using at least the stress analysis method (Section I-2000) or the deterministic fracture mechanics analysis method (Section I-3000) to demonstrate that the applicable criteria are satisfied. The techniques described in Section I-2000 were validated in WCAP-16589-P (Reference 2). The stress analysis in WCAP-16589-P was reviewed. The stress analysis was performed using the design weld dimensions specific to Wolf Creek. This analysis demonstrated that the hoop and axial stresses on the nozzle inside and outside surfaces remain below 20 ksi (tensile) over the entire region outside the alternative examination zone. When the WCAP-16589-P analysis was compared to the requirements of Section I-2000, Stress Analysis, it was determined that the requirements of I-2000 were met. The fracture mechanics analysis in WCAP-16589-P was also reviewed and compared to the requirements of I-3000. Since the alternative examination zone is below the J-groove weld, the applicable requirements are those of I-3200. The operating temperature of the head has not changed since the analysis in WCAP-16589-P was performed. After the review and comparison, it was determined that the technique described in Method 1 of I-3200 was met by the WCAP, except that the source used for crack growth rate was EPRI MRP-55, Revision 1, not Appendix O of the 2004 Edition of Section XI. However, since the same formula for crack growth rate is used in both EPRI MRP-55 and Appendix

O, there is no technical difference, and WCAP-16589-P does meet the technical requirements for I-3200(a).

It is also noted that for alternative examination zones that eliminate portions of Figure 2 examination zone below the J-groove weld, that I-1000 requires only the analysis method of either I-2000 or I-3000 to be performed. Although not required, the deterministic fracture mechanics analysis described in Section I-3000 was also validated in Reference 2.

**5.1 Stress Analysis in Accordance with ASME Code Case N-729-1 Section I-2000**

Section I-2000 of ASME Code Case N-729-1 requires that plant-specific analysis demonstrate that the hoop and axial stresses remain below 20 kips per square inch (ksi) (tensile) over the entire region outside the alternative examination zone but within the examination zone defined in Figure 2 of the Code Case.

The distance below the J-groove weld that requires examination, as determined by the point at which the CRDM penetration hoop stress distribution for the operating stress levels is less than 20 (ksi) tension, was obtained from Appendix A of Reference 2. Note that hoop stresses during steady state operation are much greater than the axial stresses.

The hoop stress distribution plots for penetrations 77 and 78 are provided in Figure 2 of this submittal. The hoop stress distribution plots in Figure 2 indicate that the minimum achievable inspection coverage below the bottom of the J-groove weld insures stresses remain below 20 ksi tensile over the entire region outside the alternative examination zone but within the examination zone defined in Figure 2 of ASME Code Case N-729-1. The hoop stress distribution plots display the downhill side as this is more limiting. Also, stress distribution plots shown are for the inside and outside surface. Table 3 summarizes the distance from below the toe of the downhill side J-groove weld to where both the inside and outside surface hoop stress drops below 20 ksi for penetrations 77 and 78.

**Table 3: Distance Below Toe of Downhill Side J-Groove Weld Where Hoop Stress is Less Than 20 KSI**

Penetration Nozzle No.	Source	Distance Below Toe of Downhill Side J-Groove Weld Where Hoop Stress < 20 ksi (inch)
77 and 78	Figure 2	0.30

**5.2 Deterministic Fracture Mechanics Analysis in Accordance with ASME Code Case N-729-1 Section I-3200, Method 1**

A fracture mechanics analysis was performed and documented in Reference 2. The analysis demonstrates that a potential axial crack in the unexamined zone will not grow



to the toe of the J-groove weld prior to the examination frequency specified in Table 1 of ASME Code Case N-729-1.

(NOTE: WCAP-16589-P was prepared prior to approval to use Code Case N-729-1. WCAP-16589-P referenced EPRI MRP-55 as the source for the crack growth formula used in the analysis, not Appendix O as required by Code Case N-729-1. However, since the same formula for crack growth rate is used in both EPRI MRP-55 and Appendix O, there is no technical difference, and WCAP-16589-P does meet the technical requirements for I-3200(a).)

- (1) The following table provides the dimensions for nozzles 77 and 78 for both the designed and as-built configurations. The actual weld height was measured using the ultrasonic test data and is listed for the as-built dimension.

<b>Penetration Nozzle Number</b>	<b>As-designed (inches)</b>	<b>As-built (inches)</b>
77	1.46	1.98
78	1.46	2.04

The flaw evaluation in WCAP-16589-P is based on the as-designed J-groove weld dimensions which assumed a smaller weld throat than the as-built condition. Often, the as-built fillet weld dimension on the downhill side of the CRDM nozzle is larger than the as-designed dimension because of access issues during fabrication. When the weld extends further down the outside surface of the head penetration nozzle due to a larger than as-designed fillet, it does not negatively affect the distance below the J-groove weld required for coverage. An assessment was performed on similar CRDM design/configuration and showed that larger as-built J-groove welds have a reduced stress profile relative to smaller welds and also required lesser distance below the weld bottom for a transition to below 20 ksi. The cases considered were for weld heights of 1.46", 2.35" and 2.97" which were analyzed to determine their resulting stress profiles below the weld. The 20 ksi criterion is reached in shorter distance for the larger fillet welds. Therefore, the 1.46" as-design dimension bounds the as-built dimensions of the CRDM nozzles for the current flaw evaluation.

The fracture mechanics analysis was performed using input from the previously discussed stress analysis. The results of the analysis are shown as flaw tolerance charts, which can be used to determine minimum required inspection coverage. This ensures that any flaws initiated below the weld, in the region of the penetration nozzle not being inspected, would not reach the bottom of the weld before the next inspection. The flaw tolerance chart for penetrations 77 and 78 is presented in Figure 3.

The flaw tolerance chart in Figure 3 demonstrates that a postulated through-wall flaw at the bottom edge of the proposed alternative examination zone will not grow to the toe of the J-groove weld within an inspection interval of four refueling cycles. The crack growth prediction shows greater than six effective full power years (EFPY) of operation required to grow the postulated flaw to the toe of the weld. Additionally, the assumed initial upper extremity locations of axial through-wall flaws are conservative based on achievable inspection coverage, because the assumed upper crack extremities are located within the achievable inspection zone.

Examination of portions of the nozzle significantly below the J-groove weld is not pertinent to the phenomena of concern, which include leakage through the J-groove weld and circumferential cracking in the nozzle above the J-groove weld. In all cases, the measured coverage is adequate to allow WCGS to continue to operate prior to the hypothetical flaws reaching the J-groove weld. In accordance with 10 CFR 50.55a(g)(6)(ii)(D) requirements, the next required examination (RF23 volumetric) would be completed prior to potential flaw propagation into the J-groove welds.

### **5.3 Surface Examination**

10 CFR 50.55a(g)(6)(ii)(D)(3) states in part that "if a surface examination is being substituted for a volumetric examination on a portion of a penetration nozzle that is below the toe of the J-groove weld, the surface examination shall be of the inside and outside wetted surface of the penetration nozzle not examined volumetrically."

To reduce personnel radiation exposure, the nozzles are typically inspected using remotely operated volumetric examination equipment. Although dye penetrant testing of threaded surfaces is possible, it is not practical. The threaded outside diameter makes a dye penetrant examination on the lower section of the penetration impractical because of excessive bleed out from the threads. Eddy current examination would similarly not be effective due to the threaded configuration. Current known radiation levels under the RVCH are 4.5 Rem/hr at the bottom of 1 CRDM nozzle. This could result in an exposure of approximately 1.5 Rem per nozzle using 4500 mRem/hr and 20 minutes/nozzle. At this time our estimates of dose rates (based on recent measurements in the area) range from 4.5 Rem/hr to 10 Rem/hr at the bottom of the CRDM nozzles, the expected dose ranges from approximately 1.5 Rem to 3.3 Rem per nozzle to perform surface examination.

Therefore, no alternative is proposed for the two CRDM nozzles with limited examination coverage below the J-groove weld.

Shielding to some extent is possible but would do little to reduce the overall whole body submersion exposure of 2400 mRem/hr as shown in survey WCNO-1610-0192. Therefore it would be impractical to install shielding at this location, due to the additional dose consumed installing the shielding being greater than the resultant savings.

### **6. Duration of Proposed Alternative**

The alternative requirements of this request will be applied for the remaining duration of the current Fourth 10-year Inservice Inspection (ISI) Interval which ends on September 2, 2025.

### **7. Precedents**

Similar relief requests have been granted to the following plants:

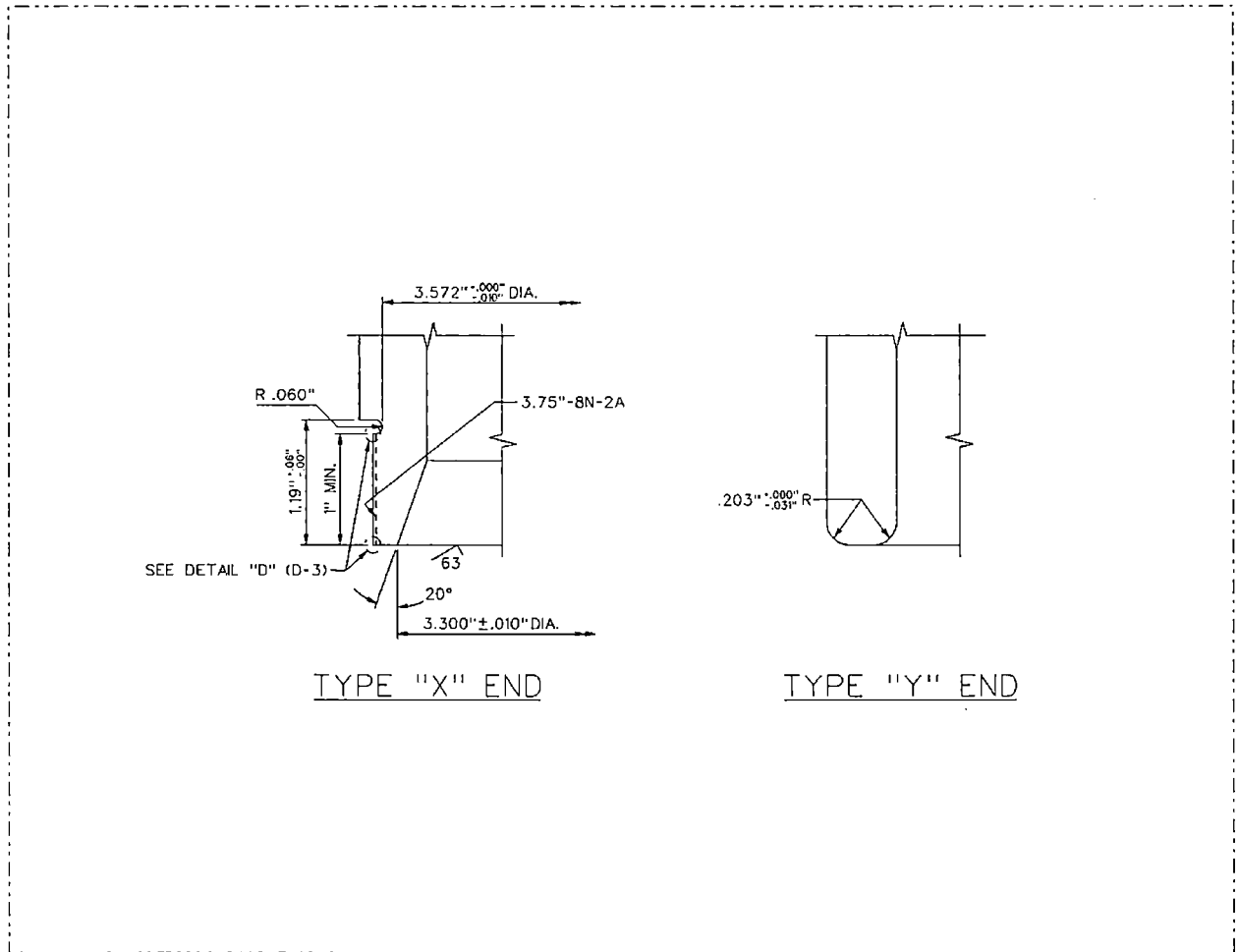
- NRC Safety Evaluation dated December 22, 2009, for San Onofre Nuclear Generating Station, Units 2 and 3, "Relief Request ISI-3-29, Request for Relief from Inspection Requirements of ASME Code Case N-729-1 for Control Element Drive Mechanism Penetrations (TAC Nos. ME0768 and ME0769)" (ML093441035)
- NRC Safety Evaluation dated March 3, 2011, for Braidwood Station Units 1 and 2, and Byron Station Units 1 and 2, "Relief Request from ASME Code Case N-729-1 Requirements for Examination of Reactor Vessel Head Penetration Welds (TAC Nos. ME3510, ME3511, ME3512 and ME3513)" (ML110590921)
- NRC Safety Evaluation dated January 4, 2013, for Wolf Creek Generating Station, "Wolf Creek Generating Station – Request for Relief No. 13R-07 for the Third 10-Year Inservice Inspection Program Interval (TAC No. ME9078)

**8. References**

1. ASME Code Case N-729-1, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1," March 28, 2006.
2. WCAP-16589-P, Revision 0, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Wolf Creek," August 2006.
3. WCNOG letter ET 06-0035 from T. J. Garrett, WCNOG, to USNRC, "Relaxation Request from the First Revised NRC Order EA-03-009 Regarding Requirements for Nondestructive Examination of Nozzles Below the J-Groove," October 5, 2006.
4. WCNOG letter ET 06-0048 from T. J. Garrett, WCNOG, to USNRC, "Additional Information Related to the First Revised NRC Order EA-03-009 Regarding Requirements for Nondestructive Examination of Nozzles Below the J-Groove," November 1, 2006.
5. NRC letter from D. Terao, USNRC, to R. A. Muench, WCNOG, "Wolf Creek Generating Station – Request to Relax Nondestructive Examination of Reactor Pressure Vessel Head Penetration Nozzles in First Revised Order EA-03-009 (TAC NO. MD3210)," December 7, 2006.
6. NRC letter EA-03-009, "Issuance Of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements For Reactor Pressure Vessel Heads At Pressurized Water Reactors," February 20, 2004.
7. WCNOG letter ET 12-0010 from J. P. Broschak, WCNOG, to USNRC, "10 CFR 50.55a Request Number 13R-07, Relief from ASME Code Case N-729-1 Requirements for Examination Of Reactor Vessel Head Penetration Welds," July 2, 2012.
8. WCNOG letter ET 12-0024 from J. P Broschak, WCNOG, to USNRC, "Response to Request for Additional Information Regarding 10 CFR 50.55a Request Number 13R-07 " Relief from ASME Code Case N-729-1 Requirements for Examination of Reactor Vessel Head Penetration Welds," October 15, 2012.
9. NRC letter from M. T. Markley, USNRC, to M. W. Sunseri, WCNOG, "Wolf Creek Generating Station - Request for Relief No. 13R-07 for the Third 10 Year Inservice Inspection Program Interval (TAC NO. ME9078)," January 4, 2013.

Figure 1

WCGS Reactor Vessel Head Penetration Ends



Details of the threaded and tapered portions of Penetrations 74, 75, 76, 77, and 78 referred to as "Type X" and the end of Penetrations 1 through 73, referred to as "Type Y."

Figure 2

Hoop Stress Distribution Downhill Side  
(48.7° CRDM Penetration Nozzle)

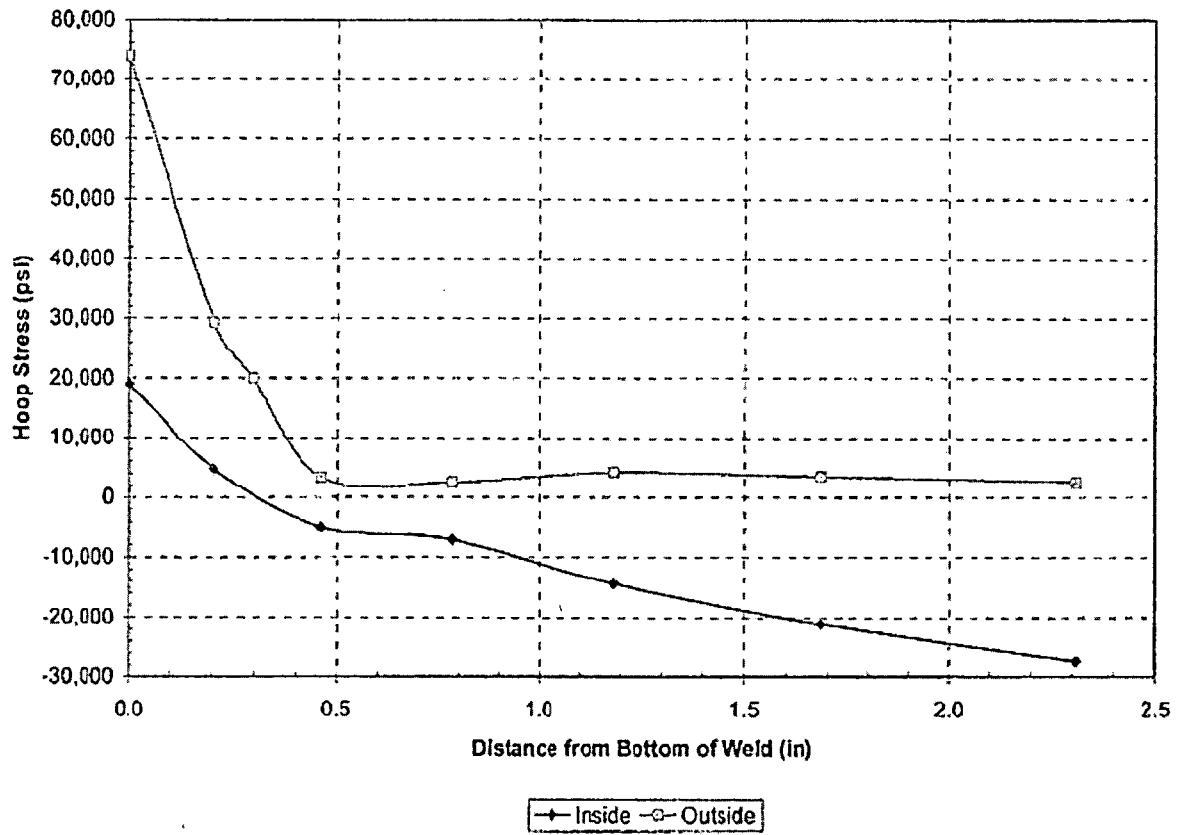


Figure 3

Crack Growth Prediction for WCGS for Through-Wall Longitudinal Flaws Located in the 48.7° Row of CRDM Penetrations, Downhill Side

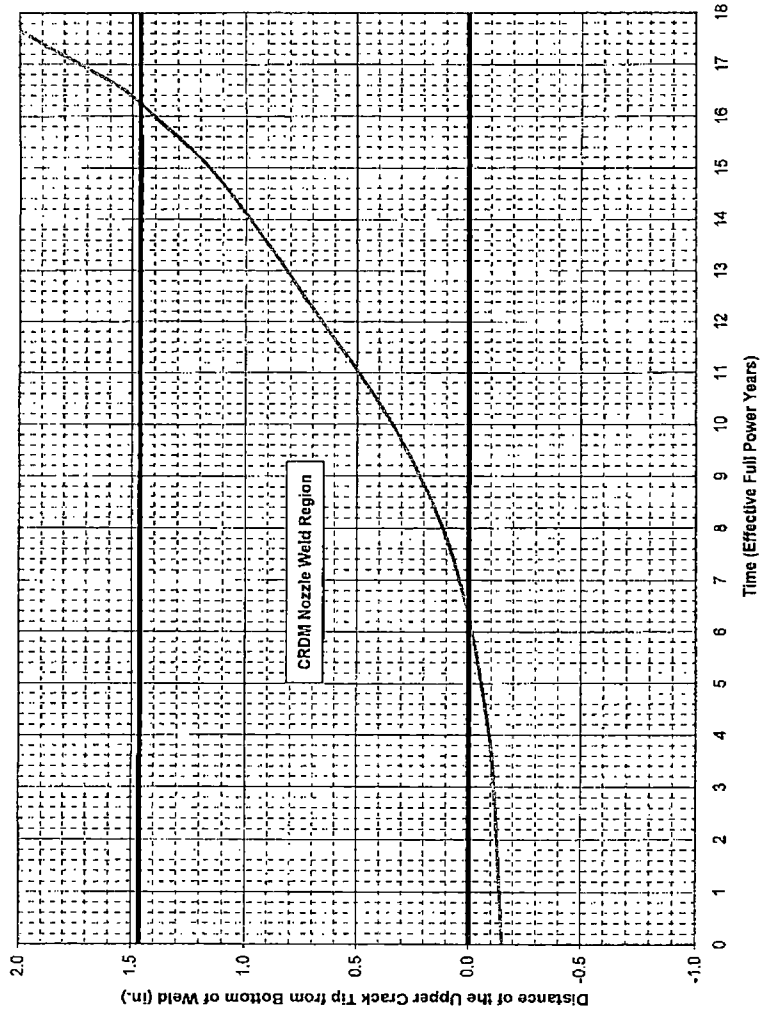


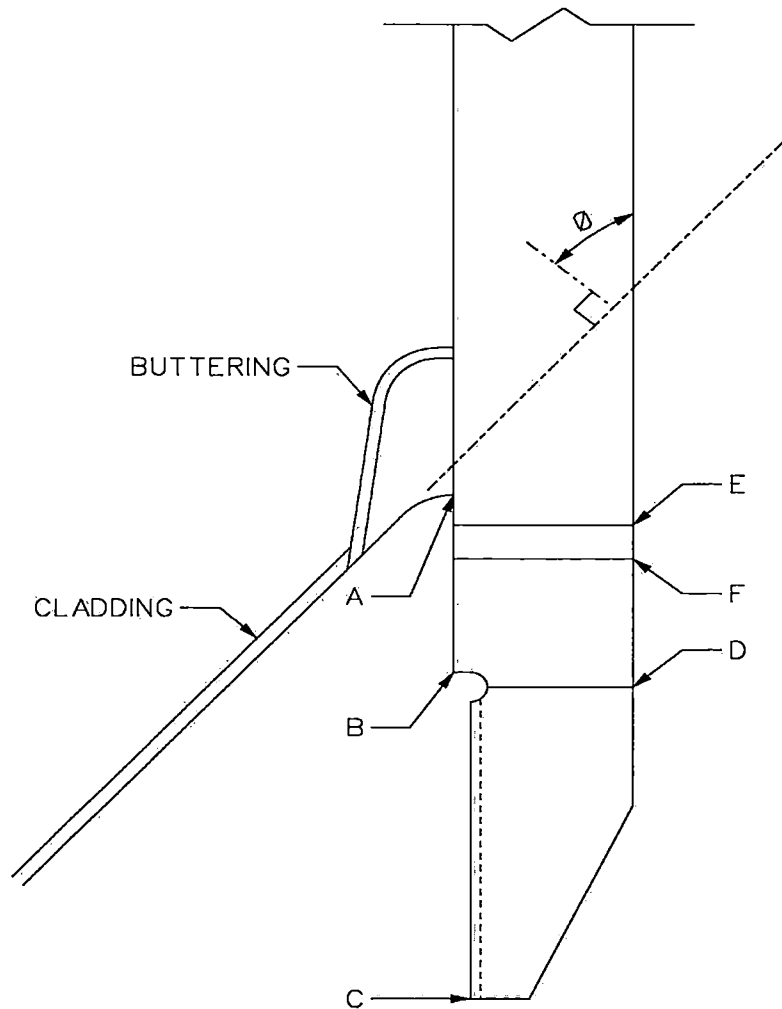
Figure 6-16 Through-Wall Longitudinal Flaws Located in the 48.7 Degrees CRDM Row of Penetrations, Downhill Side - Crack Growth Predictions for Wolf Creek

6-24

Flaw Tolerance Charts

August 2006  
WCAP-16589-NP Rev. 0

**Figure 4**  
**Relationship of the J-groove Weld to the Threaded Area**



$\Theta = 48.7^\circ$

B – C = Threaded region = 1.19"

A – E = 0.15" (A postulated through wall flaw tip at this point will not reach the bottom of the weld until 6 EFPYs)

F = 0.3" below the toe of the J-groove weld. The nozzle tube below this point has less than 20 ksi tension.

D = Lower extent of volumetric examination (center of the thread relief area)

B – D = 0.03"

D – C = 1.16"

For Penetration 77

A – D = 0.6" = the measurement using both the Axial and Circumferential scan data

For Penetration 78

A – D = 0.88" = the measurement using the Circumferential scan data

A – D = 0.64" = the measurement using the Axial scan data