Duke Energy

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October 18, 2001

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

Subject: Oconee Nuclear Station Unit 3
Docket Number 50-287
Request for Alternates to ASME Section XI per 10 CFR 50.55(a)(3) -
Relief Requests 01-14, Revision 0, and 01-15, Revision 0

Duke Energy Corporation (Duke) hereby submits Relief Request 01-14, Revision 0 (Attachment A) per 10 CFR 50.55(a)(3)(i), and Relief Request 01-15, Revision 0 (Attachment B) per 10 CFR 50.55(a)(3)(ii). By these requests, Duke is seeking relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 1989 as described below.

During the Oconee Unit 3 (ONS-3) End-of-Cycle 19 Refueling Outage planned for November 10, 2001, Duke will be performing a qualified visual examination of the Control Rod Drive Mechanism nozzle penetrations. In the event that these examinations of the reactor vessel head penetrations reveal flaws that require repair, Duke is planning to use the methods described in the attached relief requests for nozzle repairs. The planned repair is similar to the repairs performed at Oconee Station Unit 2 in May and June of 2001.

The repair process will remove the portion of the Control Rod Drive Mechanism nozzle that extends below the inner surface of the head. A new weld application surface will be prepared at a point above the heat affected zone of original pressure boundary weld within the bore through which the nozzle is installed. A new nozzle-to-head weld will be installed within the head bore by remote machine welding. The original weld is not part of the new pressure boundary weld. The original weld will be left in place at the junction of the head nozzle bore to head inside surface and analyzed for acceptability.

Relief Request 01-14, Revision 0 (Attachment A), proposes performing the repair with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding process and the ambient temperature temper bead method with 50°F minimum preheat temperature and no post weld heat treatment.

It is assumed that flaws will remain in the original nozzle to head weld, which will not be removed. As allowed by the 1989 Edition of Section XI, IWA-4120(c), Duke will use the rules of the 1992 Edition of ASME Section XI, IWA-4310 for defect evaluation. Relief Request 01-15, Revision 0 (Attachment B), is seeking relief from the evaluation of actual flaw characteristics as defined in ASME Section XI, IWA-3300(b), IWB-3142.4 and IWB-3420. In lieu of fully

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characterizing the remaining cracks, Duke proposes, in the relief request, to utilize worst-case assumptions to conservatively estimate the crack extent and orientation.

Duke is respectfully requesting review and approval of these relief requests by November 26, 2001.

This letter establishes no new regulatory commitments.

If you have any questions regarding this submittal, please contact Robert Douglas at 864-885-3073.

Very Truly Yours,

William R. McCollum, Jr.
Site Vice-President,
Oconee Nuclear Station

Attachments:

A. Oconee Unit 3 Relief Request 01-14, Revision 0
B. Oconee Unit 3 Relief Request 01-15, Revision 0

xc w/att:

NRR Project Manager
Regional Administrator, Region II

xc w/o att:

Senior Resident Inspector
South Carolina Dept. of Health & Environmental Control

ATTACHMENT A

INSERVICE INSPECTION
OCONEE UNIT 3
RELIEF REQUEST 01-14, REVISION 0
THIRD TEN-YEAR INTERVAL

OCONEE UNIT 3
INSERVICE INSPECTION
RELIEF REQUEST 01-14, REVISION 0
THIRD TEN-YEAR INTERVAL

REFERENCE CODE: The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section XI, 1989 Edition with no Addenda.

I System/Component(s) for Which Relief is Requested:

a) Name of component:
Reactor Pressure Vessel (RPV) Closure Head Control Rod Drive Mechanism (CRDM) nozzle penetrations. There are 69 Vessel Head Penetrations (VHP) on the RPV Closure head (RVH).

b) Function:
These welds serve as the pressure boundary weld for the CRDM nozzle and Reactor Vessel Head penetration.

c) ASME Code Class:
The RPV and CRDM Nozzle Penetrations are ASME Class 1.

d) Category:
Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels; Item No. B4.12.

II Current Code Requirement and Relief Request:

a) ASME B&PV Code, Section XI 1992 Edition, subparagraph IWA-4170(b) requires repairs to be made in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later Editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used. If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4200 and IWA-4400 or IWA-4500 may be used for Class 1 components.

b) In accordance with 10CFR50.55a(a)(3)(i), Duke Energy Corporation (Duke) is requesting relief from the following portion of ASME Section XI, subparagraph IWA-4170(b) to perform RPV CRDM nozzle penetration repairs: "If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4200 and IWA-4400 or IWA-4500 may be used for Class 1 components." As an alternative, Duke is proposing to perform the repair with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature temper bead method with 50°F minimum preheat

temperature and no post weld heat treatment. The description of the proposed alternative is provided in the following section.

c) Duke has determined that the proposed alternative will provide an acceptable level of quality and safety, while allowing significant dose reductions.

III Alternate Criteria for Acceptability:

Duke plans to perform CRDM nozzle penetration repairs by welding the RPV Head (P-No. 3) and CRDM nozzle (P-No. 43) base materials with (F-No. 43) filler material. The proposed alternative to the applicable portion of ASME, Section XI is the application of the methodology for ambient temperature temper bead repair outlined in Code Case N-638. Duke is not requesting approval to use the as-written Code Case for this application, but rather to apply the methodology to a partial penetration weld, which was not specifically addressed by the Code Case. Since the methodology was originally written to address repairs to full penetration welds in Reactor Vessels, and the application for Oconee Unit 3 (ONS-3) involves making new partial penetration welds in Reactor Vessel Head, some of the as-written requirements either do not apply or require substitution of equivalent requirements applicable to partial penetration welds. Therefore, the following text has been prepared using the Code Case methodology as a template, with the specific criteria applicable to this modification identified and appropriately dispositioned. Clarifications to Code Case template are made in Italics font.

1.0 GENERAL REQUIREMENTS

(a) The maximum area of an individual weld based on the finished surface will be 100 square inches, and the depth of the weld will not be greater than one-half of the ferritic base metal thickness.

(b) Repair/replacement activities on a dissimilar-metal weld in accordance with these rules are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8 inch or less of nonferritic weld deposit exists above the original fusion line.

(c) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed in accordance with these rules, provided the depth of repair in the base material does not exceed 3/8 inch.

(d) Prior to welding the area to be welded and a band around the area of at least 1½ times the component thickness or 5 inches, whichever is less, will be at least 50°F.

(e) Welding materials will meet the Owner's Requirements and the Construction Code and Cases specified in the repair/replacement plan. Welding materials will be controlled so that they are identified as acceptable until consumed.

(f) Peening may be used, except on the initial and final layers.

Note that peening will not be performed for the nozzle repair. Therefore, this requirement is not applicable.

2.0 WELDING QUALIFICATIONS

The welding procedures and the welding operators shall be qualified in accordance with Section IX and the requirements of paragraphs 2.1 and 2.2.

2.1 Procedure Qualification

(a) The base materials for the welding procedure qualification will be of the same P-Number and Group Number, as the materials to be welded. The materials shall be post weld heat treated to at least the time and temperature that was applied to the materials being welded.

(b) Consideration shall be given to the effects of welding in a pressurized environment. If they exist, they shall be duplicated in the test assembly.

Note that the nozzle repair will not be performed in a pressurized environment. Therefore, this requirement is not applicable.

(c) Consideration will be given to the effects of irradiation on the properties of material, including weld material for applications in the core belt line region of the reactor vessel. Special material requirements in the Design Specification will also apply to the test assembly materials for these applications.

Note that no repair welding will be performed in the core belt line region of the reactor vessel. Therefore this requirement has been considered, but is not applicable.

(d) The root width and included angle of the cavity in the test assembly will be no greater than the minimum specified for the repair.

(e) The maximum interpass temperature for the first three layers of the test assembly will be 150°F.

(f) The test assembly cavity depth will be at least one-half the depth of the weld to be installed during the repair/replacement activity and at least 1 inch. The test assembly thickness will be at least twice the test assembly cavity depth. The test assembly will be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity will be at least the test assembly thickness and at least 6 inches. The qualification test plate will be prepared in accordance with Figure 1.

(g) Ferritic base material for the procedure qualification test will meet the impact test requirements of the Construction Code and Owner's Requirements. If such Requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material, at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in subparagraph (i), but shall be in the base metal.

(h) Charpy V-notch tests of the ferritic weld metal of the procedure qualification shall meet the requirements as determined in subparagraph (g) above.

Note that no ferritic weld metal will be used. Therefore this requirement is not applicable.

(i) Charpy V-notch tests of the ferritic heat-affected zone (HAZ) will be performed at the same temperature as the base metal test of subparagraph (g). Number, location, and orientation of test specimens will be as follows:

1. The specimens will be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The test coupons for HAZ impact specimens will be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimens will be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. When the material thickness permits, the axis of a specimen will be inclined to allow the root of the notch to be aligned parallel to the fusion line.

2. If the test material is in the form of a plate or a forging, the axis of the weld will be oriented parallel to the principal direction of rolling or forging.

3. The Charpy V-notch test will be performed in accordance with SA-370. Specimens will be in accordance with SA-370, Figure 11, Type A. The test will consist of a set of three full-sized 10 mm x 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens will be reported in the Procedure Qualification Record.

(j) The average values of the three HAZ impact tests will be equal to or greater than the average values of the three unaffected base metal tests.

2.2 Performance Qualification

Welding operators will be qualified in accordance with ASME Section IX.

3.0 WELDING PROCEDURE REQUIREMENTS

The welding procedure shall include the following requirements:

(a) The weld metal will be deposited by the automatic or machine GTAW process.

(b) Dissimilar metal welds shall be made using A-No. 8 weld metal (QW-442) for P-No. 8 to P-No. 1, 3, or 12(A, B, or C) weld joints or F-No. 43 weld metal (QW-432) for P-No. 8 or 43 to P-No. 1, 3, or 12 (A, B, or C) weld joints.

Note that the dissimilar metal welds will be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints.

(c) The area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8 inch. overlay thickness as shown in Figure 2, steps 1 through 3, with the heat input for each layer controlled to within ±10% of that used in the procedure qualification test. Particular care will be taken in placement of the weld layers at the weld toe area of the ferritic material to ensure that the HAZ and ferritic weld metal are tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification. For similar-metal welding, the completed weld shall have at least one layer of weld reinforcement deposited. This reinforcement shall be removed by mechanical means, so that the finished surface is essentially flush with the surface surrounding the weld (Figure 3 [of CC N-638]).

Note that the final two sentences, including Figure 3, of the paragraph above are not applicable since no similar-metal welding will be performed.

(d) The maximum interpass temperature for field applications will be 350°F regardless of the interpass temperature during qualification.

Proposed: The maximum interpass temperature for field applications will be 350°F, verified by calculation rather than thermocouple measurement, regardless of the interpass temperature during qualification.

Justification: The new weld is inaccessible for mounting thermocouples near the weld. Therefore, thermocouples will not be used to monitor interpass temperature. In lieu of using thermocouples for interpass temperature measurements, calculations show that the maximum interpass temperature will never be exceeded based on a maximum allowable low welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to near ambient temperature. Heat input beyond the third layer will not have a metallurgical affect on the low alloy steel HAZ.

The calculation is based on a typical inter-bead time interval of approximately five minutes. The five minute inter-bead interval is based on the time: 1) required to explore the previous weld deposit with the two remote cameras housed in the weld head, 2) the time to shift the starting location of the next weld bead circumferentially away from the end of the previous weld-bead, and 3) the time to shift the starting location of the next bead axially to insure a 50% weld bead overlap required to properly execute the temper bead technique.

A welding mockup on a full size closure head was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the head during welding. Thermocouples were placed on the outside surface of the closure head within a 5-inch band surrounding the CRDM nozzle. Three other thermocouples were placed on the closure head inside surface. One of the three thermocouples was placed 1-1/2 inches from the CRDM nozzle penetration, on the lower hillside. The other inside surface thermocouples were placed

at the edge of the 5-inch band surrounding the CRDM nozzle, one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 15°F throughout the 18-hour welding cycle. Based on past experience, it is believed that the temperature fluctuation was due more to the resistance heating temperature variations than the low heat input from the welding process. For the closure head mockup application 300°F minimum preheat temperature was used. Therefore, for ambient temperature conditions used for this repair, maintenance of the 350°F maximum interpass temperature will not be a concern.

(e) Particular care will be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas will be suitably controlled.

4.0 EXAMINATION

(a) Prior to welding, a surface examination will be performed on the area to be welded.

(b) The final weld surface and the band around the area defined in Paragraph 1.0(d) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with Appendix I.

Proposed: The final weld will be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination will be in accordance with ASME Section III, Subsection NB-5000. However, the band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld.

Justification: The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. In the case of this repair, the repair welding will be performed remotely from the known defect. The final examination of the new weld repair and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy reactor vessel (RV) head material due to the welding process.

(c) Areas from which weld-attached thermocouples have been removed will be ground and examined using a surface examination method.

Proposed: Preheat temperature will be monitored using contact pyrometers on accessible portions of the closure head external surface(s).

Justification: The closure head preheat temperature will be essentially the same as the reactor building ambient temperature therefore closure head preheat temperature monitoring in the weld region is unnecessary and just results in additional personnel dose associated with thermocouple placement and removal.

(d) NDE personnel will be qualified in accordance with IWA-2300.

(e) Surface examination acceptance criteria will be in accordance with NB-5350. Ultrasonic examination acceptance criteria will be in accordance with IWB-3000. Additional acceptance criteria may be specified by the Owner to account for differences in weld configurations.

Proposed: Surface examination acceptance criteria will be in accordance with NB-5350. Ultrasonic examination acceptance criteria will be in accordance with NB-5330. Additional acceptance criteria may be specified by the Owner to account for differences in weld configurations.

Justification: Since ASME XI, IWB-3000 does not provide acceptance criteria for ultrasonic and surface examinations of partial penetration welds in RV heads, ASME Section III, NB-5000 will be used to evaluate indications.

5.0 DOCUMENTATION

Repair will be documented on Form NIS-2.

IV Basis for Relief:

The basis for the proposed relief request is that for the proposed application, the use of an ambient temperature temper bead welding process provides an equivalent acceptable level of quality and safety to the temper bead welding process in ASME, Section XI. In support of this conclusion, the repair process is described below, followed by technical justification for the differences between the two techniques, as well as the expected dose savings.

Description of the repair process and basis:

a) Visual inspections for leakage/boric acid deposits of CRDM nozzle penetrations will be conducted during the End-of Cycle 19 refueling outage. CRDM nozzles determined to have through-wall leakage will be repaired. Remote machine repair processes similar to those used at Oconee Unit 2 are planned.

b) Nondestructive examinations utilizing ultrasonic methods are planned for the base metal of the nozzles determined to have through-wall leakage.

c) Using a remote tool from above the RPV head, each of the leaking nozzles will first receive a roll expansion into the RPV head base material to insure that the nozzle will not move during the repair operations. Second, a semi-automated machining tool operating underneath the RV head will remove the entire lower portion of the CRDM nozzle to a depth above the existing J-groove partial penetration weld. The machine tool will also form the CRDM nozzle repair weld preparation. The operation will sever the existing J-groove partial penetration weld from the subject CRDM nozzles. The machine surface will be cleaned prior to liquid penetrant examination (PT). The repair weld will be performed with a remotely operated machine GTAW weld head using the ambient temperature temper bead process to install the new ERNiCrFe-7 (Alloy 52) pressure boundary weld between the shortened nozzle and the inside bore of the RPV

head base material with 50°F minimum preheat temperature as proposed above. The final weld face, not including the taper transition, will be machined or ground. The final weld will be liquid penetrant and ultrasonically examined. The final inside diameter surface of the CRDM nozzle near the new weld and the new weld will then be conditioned by abrasive water-jet machining to produce a final surface that is in compression to produce optimum resistance to primary water stress corrosion cracking.

d) The CRDM nozzle repair configuration is illustrated in Figures 3 and 4.

e) Recent experience gained from the prior performance of manual repairs of Oconee Units 1 and 3 CRDM nozzles indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel and still provide acceptable levels of quality and safety. Since Duke recognizes the importance of ALARA principles, these remote repair methods have been developed for the possibility of leaking nozzles at ONS-3.

f) This approach for repair of leaking CRDM nozzles will significantly reduce radiation dose to repair personnel while still maintaining acceptable levels of quality and safety. The total radiation dose (assuming four nozzles for estimation purposes) for the proposed remote repair method is projected to be about 25 to 30 REM. Duke estimates the dose accumulated providing access, installing heating pads and performing the preheat and post weld heat treatment required by the construction code would total 11 to 12 REM. In contrast, using manual repair methods previously used for ONS-3 would result in a total radiation dose of approximately 128 REM.

g) The automated repair method described above leaves a band of ferritic low alloy steel exposed to the primary coolant. The effect of corrosion on the exposed area, both reduction in RVH thickness and primary coolant Iron (Fe) release rates, has been evaluated by Framatome-ANP (FRA-ANP) and concurred with by Duke. The results of this evaluation concluded that the total corrosion would be insignificant when compared to the thickness of the RV closure head. It was also concluded that the total estimated Fe release from a total of 69 repaired CRDM nozzles would be significantly less than the total Fe release from all other sources. Duke has determined that this extremely low rate of material loss and Fe release rates provide an acceptable level of safety.

h) An analysis of the new pressure boundary welds, using a 3-dimensional model of a CRDM nozzle located at the most severe hillside orientation was performed. The software program ANSYS (general purpose finite element program that is used industry wide) was utilized for this analysis. The ANSYS computer code is independently verified as executing properly by the solution of verification problems using ANSYS and then comparing the results to independently determined values. The analytical model included the RVH, CRDM nozzle, repair weld and remnant portions of the original Alloy 600 welds. The model is analyzed for thermal transient conditions as contained in the Babcock & Wilcox (B&W) Reactor Coolant Functional Specifications for ONS-3. The resulting maximum thermal gradients are applied to the model along with the coincident internal pressure values. The ANSYS program then calculates the stresses throughout the model (including the repair welds). The

stresses are post-processed by ANSYS routines to categorize stresses into categories that are consistent with the criteria of the ASME Code. The calculated stress values were then compared to the ASME Code, Section III, NB-3000 criteria for; 1) design conditions, 2) normal, operating, and upset conditions, 3) emergency conditions, 4) faulted conditions, 5) testing conditions, and found to be acceptable. Duke has determined that this analysis shows that the repair methodology proposed for the CRDM nozzle penetration welds provides an acceptable level of quality and safety.

i) Results of procedure qualification work undertaken to date indicate that the process produces sound and tough welds. For instance, typical tensile test results have been ductile breaks in the weld metal.

As shown below, the FRA-ANP PQR 7164 using P-No. 3, Group No. 3 base material exhibited improved Charpy V-notch properties in the HAZ from both an absorbed energy and lateral expansion perspective as compared to the unaffected base material.

Properties of PQR 7164

	Absorbed energy (ft-lbs @ 50°F)	Lateral expansion (mils @ 50°F)	Shear fracture (% @ 50°F)	Absorbed energy (ft-lbs @ 80°F)	Lateral expansion (mils @ 80°F)	Shear fracture (% @ 80°F)
Unaffected Base Material	69, 55, 77	50, 39, 51	30, 25, 30	78, 83, 89	55, 55, 63	35, 35, 55
HAZ	109, 98, 141	59, 50, 56	40, 40, 65	189, 165, 127	75, 69, 60	100, 90, 80

The absorbed energy, lateral expansion, and percent shear were significantly greater for the HAZ than the unaffected base material at both test temperatures. It is clear from these results that the GTAW temper bead process has the capability of producing acceptable repair welds.

j) Duke has concluded that quality temper bead welds can be performed with 50°F minimum preheat and no post heat treatment based on ASME committee approval of Code Case N-638 and FRA-ANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding. FRA-ANP has previously qualified the GTAW temper bead process in support of ASME approval of Code Case N-606-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique for Boiling Water Reactor (BWR) CRD Housing/Stub Tube Repairs." The qualifications were performed at room temperature with cooling water to limit the maximum interpass temperature to a maximum of 100°F. The qualifications were performed on the same P-3 Group-3 base material as proposed for the CRDM repairs, using the same filler material, i.e. Alloy 52 AWS Class ERNiCrFe-7, with similar low heat input controls as will be used in the repairs. Also, the qualifications did not include a post weld heat soak. The qualification of the ambient temperature temper bead welding process demonstrates that the proposed alternative provides an acceptable level of quality and safety.

k) The proposed alternative repair technique has been demonstrated as an acceptable method for performing RVH repairs. The ambient temperature temper bead technique has been approved by the ASME committee per Code Case N-638. The ambient temperature temper bead technique has been approved by the NRC as having an acceptable level of quality and safety and used successfully at several utilities (Duane Arnold, Nine Mile Point and Fitzpatrick).

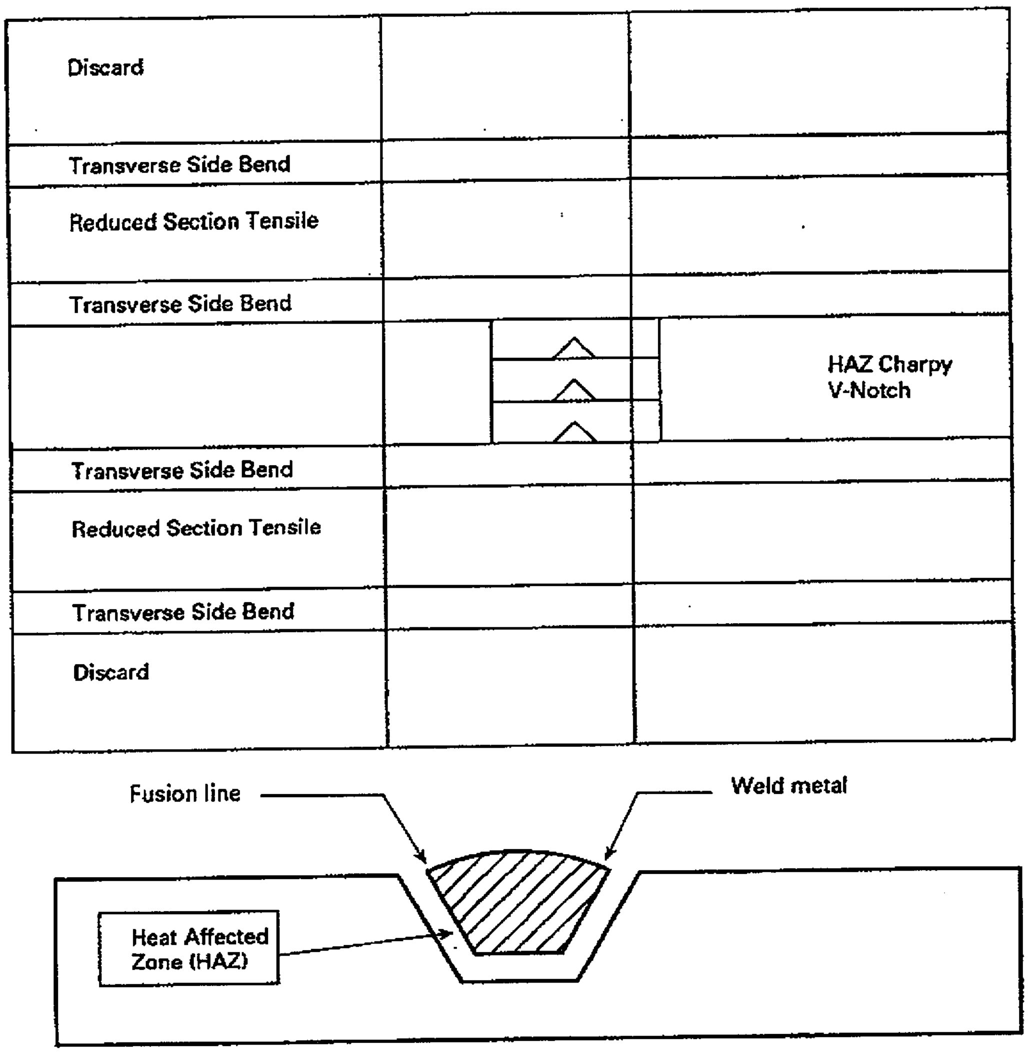
Therefore, based on the discussion above, Duke has determined that the proposed alternative provides an acceptable level of quality and safety.

V Implementation Schedule:

This Request for Alternate is associated with the repair that may be required if leaks are detected in the Unit 3 RV head CRDM nozzles. The inspections and any required repairs will be performed during the refueling outage scheduled to begin November 10, 2001.

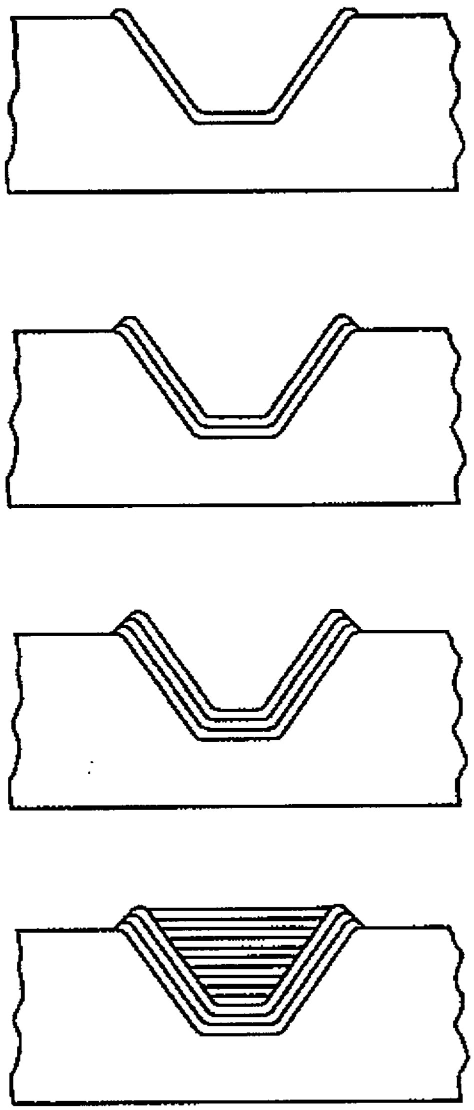
Originated by: C. R. Frye (signed) 10/15/01 Date

Reviewed by: M. L. Arey, Jr. (signed) 10/15/01 Date



GENERAL NOTE: Base metal Charpy impact specimens are not shown. This figure illustrates a similar-metal weld.

Figure 1
Qualification Test Plate



Step 1: Deposit layer one with first layer weld parameters used in qualification.

Step 2: Deposit layer two with second layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the second layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.

Step 3: Deposit layer three with third layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the third layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.

Step 4: Subsequent layers to be deposited as qualified, with heat input less than or equal to that qualified in the test assembly. NOTE: Particular care shall be taken in application of the fill layers to preserve the temper of the weld metal and HAZ.

GENERAL NOTE: The illustration above is for similar-metal welding using a ferritic filler material. For dissimilar-metal welding, only the ferritic base metal is required to be welded using steps 1 through 3 of the temperbead welding technique.

Figure 2
Machine GTAW Temper Bead Welding

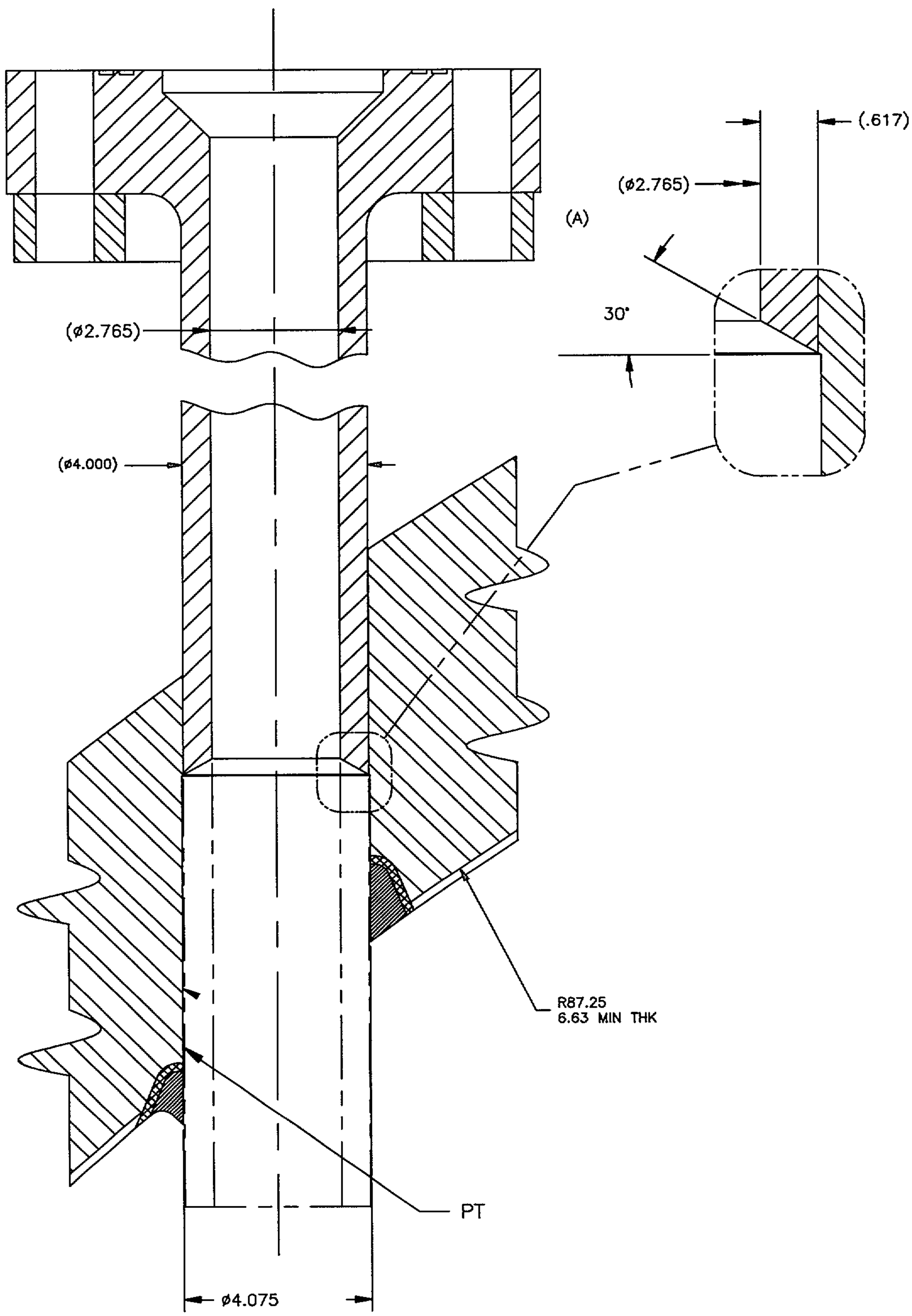


Figure 3
Oconee Unit 3 CRDM Machining

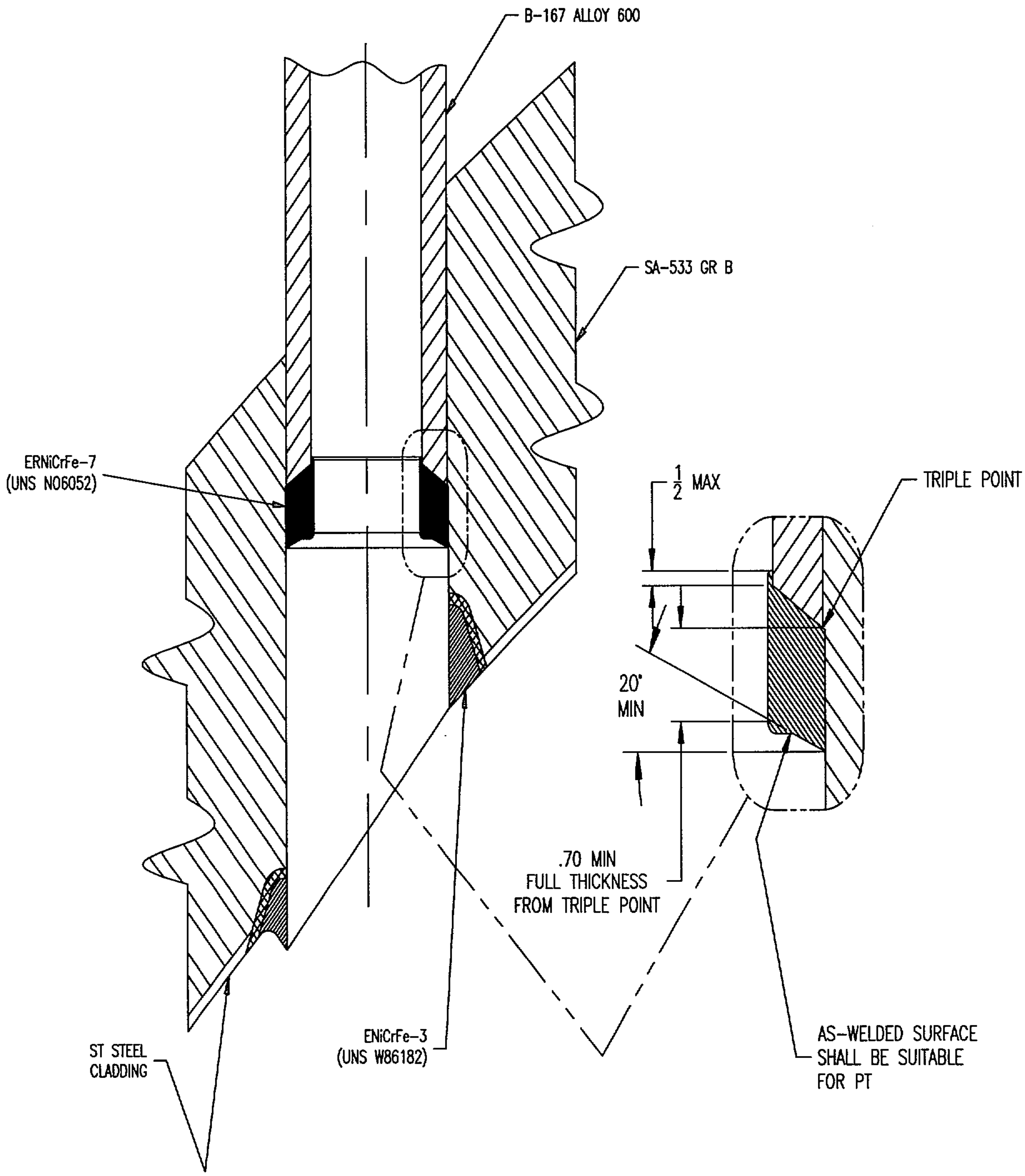


Figure 4
Oconee Unit 3 New CRDM Pressure Boundary Welds

ATTACHMENT B

INSERVICE INSPECTION
OCONEE UNIT 3
RELIEF REQUEST 01-15, REVISION 0
THIRD TEN-YEAR INTERVAL

OCONEE UNIT 3
INSERVICE INSPECTION
RELIEF REQUEST 01-15, REVISION 0
THIRD TEN-YEAR INTERVAL

REFERENCE CODE: The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section XI, 1989 Edition with no Addenda.

I System/Component(s) for Which Relief is Requested:

a) Name of component:

Reactor Pressure Vessel (RPV) Closure Head Control Rod Drive Mechanism (CRDM) nozzle penetrations. There are 69 Vessel Head Penetrations (VHP) on RPV Closure head (RVH).

b) Function:

These welds serve as the pressure boundary for the Reactor Vessel Head.

c) ASME Code Class:
The RPV and CRDM Nozzle Penetrations are ASME Class 1.

d) Category:
Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels, Item No. B4.12.

II Current Code Requirement and Relief Request:

In accordance with the provisions of ASME B&PV Code, Section XI 1989 Edition, IWA 4120(c), Duke Energy Corporation (Duke) will use the 1992 Edition of ASME B&PV Code, Section XI for IWA-4310.

IWA-4310 requires in part that, "Defects shall be removed or reduced in size in accordance with this Paragraph." Furthermore, IWA-4310 allows that "...the defect removal and any remaining portion of the flaw may be evaluated and the component accepted in accordance with the appropriate flaw evaluation rules of Section XI." The ASME Section XI, IWA-3300 rules require characterization of flaws detected by inservice examination.

Duke is requesting relief from ASME Section XI, Subsection IWA-3300. It is assumed that flaws will remain in the original CRDM to RVH J-Groove weld, which will not be removed. Duke will remove portions of the original weld to limit the size of flaws that remain. In lieu of fully characterizing the existing cracks, Duke proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation.

Section III, subsection NB-5330(b) requires that "Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length."

Duke is requesting relief from the requirements of NB-5330(b). The new pressure boundary weld that will connect the remaining portion of the CRDM nozzles to the low alloy RV closure head contains a material "triple point." The triple point is at the root of the weld where the Alloy 600 nozzle will be welded with Alloy 690 (52/152) filler material to the SA-533 Grade B, Class 1 Mn-Mo low alloy steel plate (See Figures 1 and 2). Experience has shown that during solidification of the Alloy 690 weld filler material, a lack of fusion (otherwise known as a welding solidification anomaly) area may occur at the root of the partial penetration welds.

The 1989 ASME Section III code has been adopted for the repairs described herein. Section III, subsection NB-5245 requires that partial penetration joints be examined progressively using either magnetic particle (MT) or penetrant (PT) methods. The increments of the examination shall be the lesser of ½ the welded joint thickness or ½ inch. The surface of the finished weld shall also be examined by either method.

Duke is requesting relief from ASME section III subsection NB-5245. This subsection requires a progressive MT or PT to be performed during welding.

Duke has determined that the proposed alternative will provide an acceptable level of quality and safety, while allowing significant dose reductions.

III Alternate Criteria for Acceptability:

In lieu of the requirements of IWA-3300, per 10 CFR 50.55a(a)(3)(i) the following alternative is proposed:

The planned repair for the subject CRDM nozzles does not include removal of the cracks discovered in the remaining J-groove partial penetration welds. Therefore, per the requirements of IWA-4310, the cracks must be evaluated using the appropriate flaw evaluation rules of Section XI. No additional inspections are planned to characterize the cracks. Thus, the actual dimensions of the flaw will not be fully determined. In lieu of fully characterizing the existing cracks, Duke will utilize worst-case assumptions to conservatively estimate the crack extent and orientation. The postulated crack extent and orientation will then be evaluated using the rules of IWB-3600.

If a weld triple point anomaly occurs in any of the repair welds, it must also be evaluated in accordance with the appropriate flaw evaluation rules of Section XI. Calculations have been completed which justify this welding solidification anomaly.

It is proposed that the progressive testing be eliminated and that a volumetric examination of the weld using UT be performed after the weld is completed. In addition, a PT of the surface of the finished weld will be conducted.

IV Basis for Relief:

Inspections of the reactor vessel (RV) closure head during the upcoming refueling outage in accordance with the ONS-3 response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," may discover small amounts of boron emanating from the CRDM nozzle interface with the outside radius of the closure RV head. Supplemental examinations will be performed to confirm the existence of through-wall cracks that may exist in the original J-groove partial penetration welds or in the CRDM nozzle base material at these locations.

Experience gained from the earlier repairs to the Oconee Unit 1 and Unit 3 CRDM nozzles indicated that removal and repair of the defective portions of the original J-groove partial penetration welds were time consuming and radiation dose intensive. The previous repairs indicated that more remote automated repair methods were needed to reduce radiation dose to repair personnel. For the upcoming Oconee Unit 3 (ONS-3) repairs, a remote semi-automated repair method is planned for each of the subject nozzles. Using a remote tool from above the RV head, each of the nozzles requiring repair will first receive a roll expansion into the RV head base material to insure that the nozzle will not move during subsequent repair operations. Second, a semi-automated machining tool from underneath the RV head will remove the lower portion of the nozzle to a depth above the existing J-groove partial penetration weld. This operation will sever the existing J-groove partial penetration weld from the subject CRDM nozzles. Third, a semi-automated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process, will then be used to install a new Alloy 690 pressure boundary weld between the shortened nozzle and the inside bore of the RV head base material (See Figures 1 and 2). It was intended, as a part of the new repair methodology and to reduce radiation dose to repair personnel, that the original J-groove partial penetration welds would be left in place. These welds will no longer function as pressure boundary CRDM nozzle to closure head welds. However, the possible existence of cracks in these welds mandates that the flaw growth potential be evaluated.

The requirements of IWA-4310 allow two options for determining the disposition of discovered cracks. The subject cracks are either removed as part of the repair process or left as-is and evaluated per the rules of IWB-3600. The repair design specifies the inside corner of the J-groove weld be progressively chamfered from the center to outermost penetrations to maintain an acceptable flaw size.

The assumptions of IWB-3600 are that the cracks are fully characterized to be able to compare the calculated crack parameters to the acceptable parameters addressed in IWB-3500. In the alternative being proposed, the acceptance of the postulated crack is calculated based on the two inputs of expected crack orientation and the geometry of the weld. Typically, an expected crack orientation is evaluated based on prevalent stresses at the location of interest. In these welds, operating stresses were obtained using finite element analysis of the RV closure head. Since hoop stresses were calculated to be the dominant stress, it is expected that radial type cracks (with respect to the penetration) will occur. Using worst case (maximum) assumptions with the geometry of the as-left weld, the postulated crack was assumed to begin at the intersection of the RV closure head inner diameter surface and the CRDM nozzle bore and propagate into the RV closure head low alloy steel. The depth and orientation are worst-case

assumptions for cracks that may occur in the remaining J-groove partial penetration weld configuration.

The original CRDM nozzle to closure head weld configuration is extremely difficult to UT due to the compound curvature and fillet radius as can be seen in Figures 1 and 2. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore it is impractical, and presently, the technology does not exist, to characterize flaw geometries that may exist therein. Not only is the configuration not conducive to UT but the dissimilar metal interface between the NiCrFe weld and the low alloy steel closure head increases the UT difficulty. Furthermore, due to limited accessibility from the closure head outer surface and the proximity of adjacent nozzle penetrations, it is impractical to scan from this surface on the closure head base material to detect flaws in the vicinity of the original weld. Duke proposes to accept these flaws by analysis of the worst case that might exist in the J-groove. Since the worst case condition has been analyzed as described below, no future examinations of these flaws is planned.

As previously discussed, after the boring and removal of the nozzle end, the remaining weld will be chamfered to assure the remaining weld metal is thinner than the maximum allowable flaw size. Since it has been determined that through-wall cracking in the J-groove weld will most likely accompany a leaking CRDM nozzle, it must be assumed that the "as-left" condition of the remaining J-groove weld includes degraded or cracked weld material.

A fracture mechanics evaluation was performed to determine if degraded J-groove weld material could be left in the vessel, with no examination to size any flaws that might remain following the repair. Since the hoop stresses in the J-groove weld are generally about two times the axial stress at the same location, the preferential direction for cracking is axial, or radial relative to the nozzle. It was postulated that a radial crack in the Alloy 182 weld metal would propagate by Primary Stress Corrosion Cracking (PWSCC) through the weld and butter, to the interface with the low alloy steel head. It is fully expected that such a crack would then blunt and arrest at the butter-to-head interface. In the worst case, on the uphill side of the nozzle, where the hoop stresses are highest and the area of the J-groove weld is the largest, a radial crack depth extending from the corner of the weld to the low alloy steel head would be very deep, up to about 1-3/4 inch at the outermost row of nozzles.

Ductile crack growth through the Alloy 182 material would tend to relieve the residual stresses in the weld as the crack grew to its final size and blunted. Although residual stresses in the head material are low, it was assumed that a small flaw could initiate in the low alloy steel material and grow by fatigue. It was postulated that a small flaw in the head would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel head by fatigue crack growth under cyclic loading conditions associated with heatup and cooldown.

Residual stresses were not included in the flaw evaluations since it was demonstrated by analysis that these stresses are compressive in the low alloy steel base metal. Any residual stresses that remained in the area of the weld following the boring operation would be relieved by such a deep crack, and therefore need not be considered.

Flaw evaluations were performed for a postulated radial corner crack on the uphill side of the head penetration, where stresses are the highest and the radial distance from the inside corner to the low alloy steel base metal (crack depth) is the greatest. Hoop stresses were used since they are perpendicular to the plane of the crack. Fatigue crack growth, calculated for 150 heat-up/cool-down cycles was minimal (about 0.100 inch), and the final flaw size met the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi√in for ferritic materials.

Based on the analysis performed, it is acceptable to leave the postulated cracks in the attachment weld (J-groove) and buttering. The calculations performed show the remaining flaws within the base material are acceptable for 150 heat-up/cool-down cycles. The only driving mechanism for fatigue crack growth of the base material is heat-up/cool-down cycles. The fracture mechanics evaluation assumes a radial (with respect to the penetration center line) crack exists with a length equal to the partial penetration weld preparation depth. Based on industry experience and operating stress levels, there is no reason for service related cracks to exist in the ferritic material.

An additional evaluation was made to determine the potential for debris from a cracking J-groove partial penetration weld. As noted above, radial cracks were postulated to occur in the weld due to the dominance of the hoop stress at this location. The occurrence of transverse cracks that could intersect the radial cracks is considered remote. There are no forces that would drive a transverse crack. The radial cracks would relieve the potential transverse crack driving forces. Hence, it is unlikely that a series of transverse cracks could intersect a series of radial cracks resulting in any fragments becoming dislodged.

The cited evaluations provide an acceptable level of safety and quality in insuring that the RV closure head remains capable of performing its design function for 150 heat-up/cool-down cycles, with flaws existing in the original J-groove weld.

For the reasons described above, areas containing flaws accepted by analytical evaluation will not be reexamined. Additionally, Duke has previously committed to replace the Oconee Units 1, 2, and 3 RVHs: The Unit 3 RVH replacement is currently scheduled for the refueling outage (end-of-cycle 20) planned for the Spring of 2003.

Welding solidification is an inherent problem when using high NiCr alloys in the presence of a notch located at the so-called triple point. IWA-4170 mandates that the repair design meets the original construction code or the adopted Section III code. As noted the 1989 ASME Section III code has been adopted for qualification of the described repairs. Subsection NB-5330(b) stipulates that no lack of fusion area be present in the weld. A fracture mechanics analysis was performed to provide justification, in accordance with Section XI of the ASME Code, for operating with the postulated weld anomaly described above. The anomaly was modeled as a 0.1 inch semi-circular "crack-like" defect, 360 degrees around the circumference at the "triple point" location. Postulated flaws could be oriented within the anomaly such that there are two possible flaw propagation paths, as discussed below.

Path 1:

Flaw propagation path 1 that traverses the CRDM tube wall thickness from the OD of the tube to the ID of the tube. This is the shortest path through the component wall, passing through the new Alloy 690 weld material. However, Alloy 600 tube material properties or equivalent were used to ensure that another potential path through the HAZ between the new repair weld and the Alloy 600 tube material is bounded.

For completeness, two types of flaws were postulated at the outside surface of the tube. A 360 degree continuous circumferential flaw, lying in a horizontal plane, was considered to be a conservative representation of crack-like defects that may exist in the weld anomaly. This flaw was subjected to axial stresses in the tube. An axially oriented semi-circular outside surface flaw was also considered since it would lie in a plane normal to the higher circumferential stresses. Both of these flaws would propagate toward the inside surface of the tube.

Path 2:

Flaw propagation path 2 runs down the outside surface of the repair weld between the weld and RV head. A semi-circular cylindrically oriented flaw was postulated to lie along this interface, subjected to radial stresses with respect to the tube. This flaw may propagate through either the new Alloy 690 weld material or the low alloy steel RV head material.

The results of the analysis demonstrated that a 0.10 in. weld anomaly is acceptable for a 20 year design life of the CRDM ID temper bead weld repair. Significant fracture toughness margins were obtained for both of the flaw propagation paths considered in the analysis. The minimum calculated fracture toughness margins, 10.8 for path 1 and 25.2 for path 2, are significantly greater than the required margin of $\sqrt{10}$ per Section XI, IWB-3612. Fatigue crack growth is minimal. The maximum final flaw size is 0.1003 in. considering both flaw propagation paths. A limit load analysis was also performed considering the ductile Alloy 600/Alloy 690 materials along flaw propagation path 1. The analysis showed limit load margins of 9.83 and 6.95 for normal/upset conditions and emergency/faulted conditions, respectively. These are significantly greater than the required margins of 3.0 and 1.5 for normal/upset conditions and emergency/faulted conditions, respectively, per Section XI, IWB-3642.

This evaluation was prepared in accordance with ASME Section XI and demonstrated that for the intended service life of the repair, the fatigue crack growth was acceptable and the crack-like indications remained stable. These two findings satisfied the Section XI criteria but do not include considerations of stress corrosion cracking such as primary water stress corrosion cracking (PWSCC) or residual stresses.

Since the crack-like defects in the weld anomaly are not exposed to the primary coolant and the air environment is benign for the materials at the triple point, the time-dependent crack growth rates from PWSCC are not applicable regardless of residual stresses.

Residual stresses may also require consideration for ductile tearing when operating stresses are superimposed. The residual stress field by itself cannot promote ductile tearing or it would not be stable during welding. The anomalies have been shown to be stable by welding mock-ups simulating the actual geometry and materials. Even though the residual stresses for this

type of weld would be very complex, it is apparent that by the size of the weld and the nature of the restraint that the residual stresses would have limited effect on driving a crack. The weld residual stresses are not like piping thermal expansion stresses where there may be considerable stored energy in long runs of pipe. The weld residual stresses are imposed by the inability of the weld bead to shrink to a nominal strain condition upon cooling. The attachment of the weld to the surrounding material generally promotes tensile stresses in the bead upon cooling. Even though the stresses are generally at the yield strength, the accompanying strains are not large due to the limited size of the beads and in this case the total size of the weld.

It is concluded that the residual stress field would produce a minimal ductile tearing driving force in the Ni-Cr-Fe materials that are extremely crack-tolerant when not in an aggressive environment. The Section XI evaluation performed is adequate, residual stresses need not be considered because PWSCC effects are not applicable, and the geometry is not conducive to sustained ductile tearing.

The twenty-year design life exceeds the time planned for replacement of the Unit 3 RV closure head (i.e. replacement planned for the Spring of 2003).

For the repair process proposed for use on the Oconee Unit 3 RV head, application of progressive surface inspection techniques, as required by IWA-4170(d), would require additional under-head entries. Twelve additional entries would be required to de-stage/re-stage the welding equipment and insert the plugs required for the penetrant test method. These additional entries would result in an estimated dose increase of 3 REM. (approximately 10% increase in total expected dose)

ASME Section III, paragraph NB-5245 requires a progressive surface examination of partial penetration welds to insure sound weld metal. The temper-bead process used for this repair would require a volumetric examination per the welding rules provided in ASME Section XI, IWA-4533. The intent of this examination is to confirm that the weld metal buildup, the fusion zone, and the parent metal opposite the weld are free of lack of fusion and laminar defects.

The UT inspection that can be performed along with the PT inspection and the weld quality provisions described above will provide an acceptable level of quality and safety.

Justification for Granting Relief

Removal of the cracks in the existing J-groove partial penetration welds would incur excessive radiation dose for repair personnel. With the installation of the new pressure boundary welds previously described, the original function of the J-groove partial penetration welds is no longer required. It is well understood that the cause of the cracks in the subject J-groove welds is PWSCC. As shown by industry experience, the low alloy steel of the RV head impedes crack growth by PWSCC. Duke believes the alternative described will provide an acceptable level of quality and safety when compared to the code requirements in IWB-3500 to characterize the cracks left in service. Using flaw tolerance techniques, it has been determined that the assumed worst-case crack size would not grow to an unacceptable depth into the RV head low alloy steel. Thus, the RV head can be accepted per the requirements of IWA-4310.

Based on extensive industry experience and Framatome ANP direct experience, there are no known cases where flaws initiating in an Alloy 82/182 weld have propagated into the ferritic base material. The surface examinations performed associated with flaw removal during recent repairs at Oconee 1 and 3 on closure head CRDM penetrations, Catawba 2 steam generator channel head drain connection penetration, ANO-1 hot leg level tap penetrations and the VC Summer Hot Leg pipe to primary outlet nozzle repair (reference MRP-44: Part I: Alloy 82/182 Pipe Butt Welds, EPRI, 2001. TP-1001491) all support the assumption that the flaws would blunt at the interface of the NiCrFe weld to ferritic base material. Additionally, the Small Diameter Alloy 600/690 Nozzle Repair Replacement Program (CE NPSD-1198-P) provides data that shows PWSCC does not occur in ferritic pressure vessel steel. Based on industry experience and operation stress levels there is no reason for service related cracks to propagate into the ferritic material from the Alloy 82/182 weld.

DEC believes that compliance with the portions of Section XI IWA-4170(d) and Section III NB-5330(b) (by reference) constitutes a hardship per 10 CFR 50.55 (a), (a)(3)(ii). It is physically impossible, using the techniques described, to install the new pressure boundary welds without the possibility of a solidification anomaly. Using the semi-automated process for repair of CRDM nozzles will significantly reduce radiation dose to repair personnel. It has been shown that the new pressure boundary welds, with the cited analyses, and the alternate examinations, are acceptable and thus demonstrate the repairs provide an acceptable level of quality and safety.

DEC believes that compliance with Section III subsection NB-5245 constitutes a hardship per 10 CFR 50.55 (a), (a)(3)(ii). The proposed alternative ultrasonic and penetrant inspection will provide an acceptable level of quality and safety without significant increase in radiation dose to repair personnel.

V Implementation Schedule:

This Request for an alternative is only applicable to the repairs of the subject Oconee Unit 3 RV head CRDM nozzles.

Originated by: C. R. Frye (signature) — Date: 10/15/01
C. R. Frye

Reviewed by: (signature) — Date: 10/15/01
M. L. Arey, Jr.

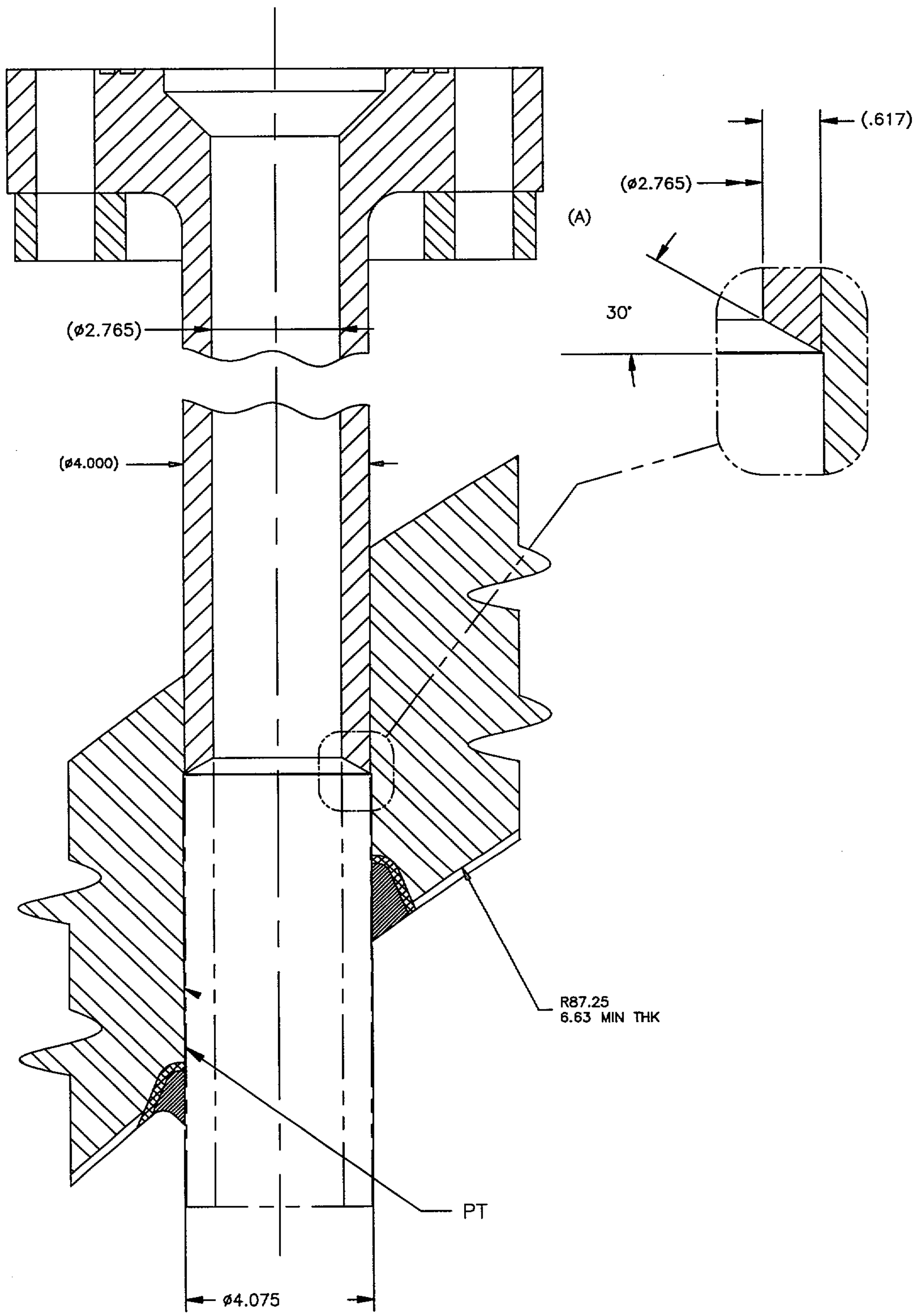


Figure 1:
Oconee Unit 3 CRDM Machining

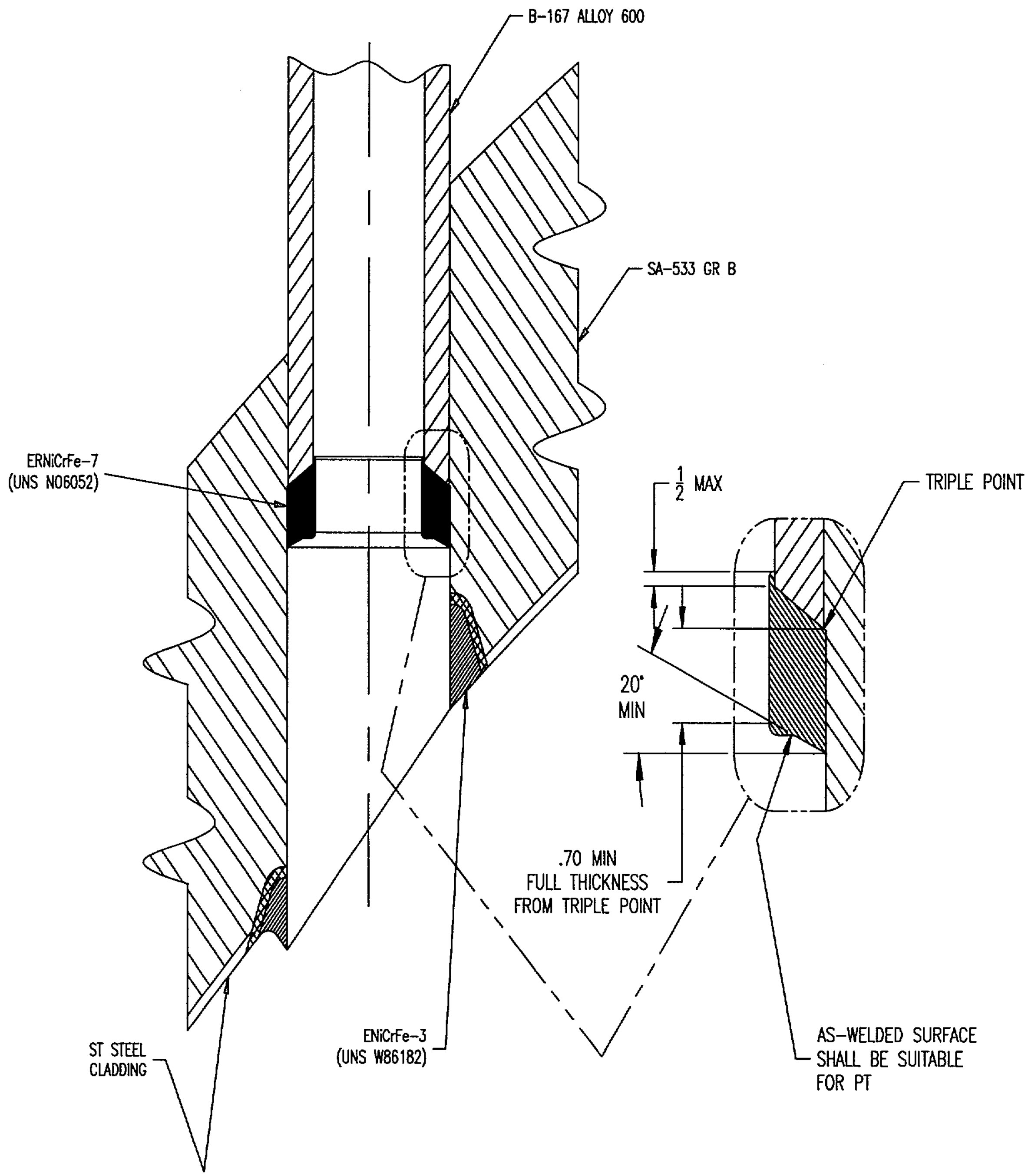


Figure 2:
Oconee Unit 3 New CRDM Pressure Boundary Welds