SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INSERVICE INSPECTION PROGRAM

RELIEF REQUEST NOS. ANO1-R&R-003 AND ANO1-R&R-004

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNIT 1

DOCKET NO. 50-313

1.0 INTRODUCTION

The Inservice Inspection (ISI) of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Class 1, Class 2, and Class 3 components is to be performed in accordance with ASME Code, Section XI "Rules for Inservice Inspection of Nuclear Power Plant Components," with applicable edition and addenda as required by 10 CFR 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). As stated in 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the U.S. Nuclear Regulatory Commission (NRC), if the applicant demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) twelve months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The Code of record for Arkansas Nuclear One, Unit 1 (ANO-1) third 10-year ISI interval is the 1992 Edition of ASME Section XI. The original code of construction for ANO-1 is ASME Section III, 1965 Edition with the Addenda through Summer, 1967. The applicable edition of ASME Section III for the third 10-year interval at ANO-1 is the 1989 Edition.

By letter dated October 28, 2002, as supplemented by letters dated November 26 and December 16, 2002, Entergy Operations, Inc. (Entergy or the licensee), submitted two requests for relief from the requirements of ASME Code Sections III and XI requirements at ANO-1. Specifically, the licensee requested relief from the ASME Code, Section III, 1989 Edition, subparagraph NB-4622 that requires elevated temperature preheat and post-weld soak, and

ASME Code, Section XI, 1992 Edition, subparagraph IWA-4310 that requires defects be removed or reduced to an acceptable size. As an alternative, the licensee proposed a repair using a remotely operated, gas tungsten-arc welding (GTAW) process. The GTAW process utilizes an ambient temperature temper bead method with a 50°F minimum preheat temperature and no post-weld heat treatment (PWHT). In addition, defects not removed from the original J-groove weldment would be analytically evaluated for acceptability using a postulated worst-case scenario.

2.0 RELIEF REQUEST NO. ANO1-R&R-003, REVISION 0

2.1 Component for Which Relief is Requested

Reactor Pressure Vessel Closure Head (RVCH) Nozzles

2.2 Code Requirements for Which Relief is Requested

The 1992 Edition of ASME Section XI, paragraph IWA-4170(b) states:

> Repairs and installation of replacement items shall be performed 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.

Because of the risk of damage to the Reactor Pressure Vessel Closure Head (RVCH) material properties or dimensions, it is not feasible to apply the PWHT requirements of paragraph NB-4622 of the 1989 ASME Section III Code to the RVCH. The alternative temper bead methods (IWA-4500 and NB-4622.10, or NB-4622.11) offered by ASME Section III and ASME Section XI require elevated temperature preheat and post weld soaks that will result in added radiation dose to repair personnel.

As an alternative to the requirements of NB-4622, Entergy proposes to perform the repair with a remotely operated weld tool, utilizing the machine GTAW process and the ambient temperature temper bead method with 50 °F minimum preheat temperature and no PWHT. The repairs will be conducted in accordance with the 1992 Edition of ASME XI (as applicable), the 1989 Edition of Section III (as applicable), and alternative requirements discussed in Relief Request No. ANO1-R&R-003.

2.3 Licensee's Proposed Alternative

The current ANO-1 refueling outage (1R17) began October 4, 2002. During this refueling outage, Entergy examined RVCH nozzles in accordance with ANO-1's response to NRC Bulletin 2002-02, "Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs." This examination identified RVCH nozzles that have indications of flaws requiring repair. The use of any of the alternatives permitted by the applicable ASME Codes for repairs will result in increased radiation dose with no compensating increase in quality or safety. The PWHT parameters required by NB-4622 would be difficult to achieve on a RVCH in containment and would pose significant risk of distortion to the geometry of the RVCH and RVCH nozzles. In addition the existing J-groove welds would be exposed to PWHT for which they were not qualified. This request applies to any nozzle requiring repair by the methods described herein.

Entergy requests relief to use an ambient temperature temper bead method of repair as an alternative to the requirements of the 1989 Edition of ASME Section III, NB-4622. As an alternative to these requirements, the requirements of, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," (Attachment 1 to the October 28, 2002, relief request) will be used. A list of the most applicable articles, subarticles, paragraphs, and subparagraphs of ASME Section III and Section XI are given below.

NB-4331 establishes the requirement that all welding procedure qualification tests be in accordance with the requirements of ASME Section IX, as supplemented, or modified by the requirements of NB-4331. The welding procedure has been qualified in accordance with the requirements of paragraphs 2.0 and 2.1 of Attachment 1 to ANO1-R&R-003. These two paragraphs are modeled on ASME Code Case N-638 and include the additional requirements of ASME Section III Paragraph NB-4335.2. No alternative to the requirements of NB-4331 is needed or proposed.

NB-4622.1 establishes the requirement for PWHT of welds including repair welds. In lieu of the requirements of this subparagraph, Entergy proposes to utilize a temper bead weld procedure obviating the need for post weld stress relief.

NB-4622.2 establishes requirements for time at temperature recording of the PWHT and their availability for review by the Inspector. The requirement of this subparagraph will not apply because the proposed alternative does not involve PWHT.

NB-4622.3 discusses the definition of nominal thickness as it pertains to time at temperature for PWHT. The subparagraph is not applicable in this case because the proposed alternative involves no PWHT.

NB-4622.4 establishes the holding times at temperature for PWHT. The subparagraph is not applicable in this case because the proposed alternative involves no PWHT.

NB-4622.5 establishes PWHT requirements when different P-number materials are joined. This subparagraph is not applicable because the proposed alternative involves no PWHT.

NB-4622.6 establishes PWHT requirements for non-pressure-retaining parts. The subparagraph is not applicable in this case because the potential repairs in question will be to pressure retaining parts. Furthermore, the proposed alternative involves no PWHT.

NB-4622.7 established exemptions from mandatory PWHT requirements. NB-4622.7(a) through NB-4622.7(f) are not applicable in this case because they pertain to conditions that do not exist for the proposed repairs. NB-4622.7(g) discusses exemptions to weld repairs to dissimilar metal welds if the requirements of NB-4622.11 are met. This subparagraph does not apply because the ambient temperature temper bead repair is being proposed as an alternative to the requirements of subparagraph NB-4622.11.

NB-4622.8 establishes exemptions from PWHT for nozzle-to-component welds and branch connection-to-run piping welds. NB-4622.8(a) establishes criteria for exemption of PWHT for connection partial penetration welds. This is not applicable to the proposed repairs because the criteria involve buttering layers at least 1/4-inch thick, which will not exist for the welds in question. NB-4622.8(b) also does not apply because it discusses full penetration welds and the welds in question are partial penetration welds.

NB-4622.9 establishes requirements for temper bead repairs to P-No. 1 and P-No. 3 materials, and A-Nos. 1, 2, 10, or 11 filler metals. The subparagraph does not apply in this case because the proposed repairs will involve F-No. 43 filler metals using GTAW instead of Shielded Metal Arc Welding (SMAW).

NB-4622.10 establishes requirements for repair welding to cladding after PWHT. The subparagraph does not apply in this case because the proposed repair alternative does not involve repairs to cladding.

NB-4622.11 discusses temper bead weld repair to dissimilar metal welds or buttering. The ambient temperature temper bead repair is being proposed as an alternative to the requirements of subparagraph NB-4622.11. As described below, elements of NB-4622.11 are incorporated into the proposed alternative.

NB-4622.11(a) requires surface examination prior to repair in accordance with NB-5000. The proposed alternative will include surface examination prior to repair consistent with NB-5000.

NB-4622.11(b) contains requirements for the maximum extent of repair including a requirement that the depth of excavation for defect removal not exceed 3/8 inch in the base metal. The proposed alternative includes the same limitations on the maximum extent of repair.

NB-4622.11(c) discusses the repair welding procedure and requires procedure and welder qualification in accordance with ASME Section IX and the additional requirements of Article NB-4000. The proposed alternative will satisfy this requirement. In addition, NB-4622.11(c) requires that the Welding Procedure Specification (WPS) include the following requirements:

NB-4622.11(c)(1) requires the area to be welded be suitably prepared for welding in accordance with the written procedure to be used for the repair. The proposed alternative will satisfy this requirement.

NB-4622.11(c)(2) requires the use of the SMAW process with covered electrodes meeting either the A-No. 8 or F-No. 43 classifications. The proposed alternative utilizes GTAW with weld filler metals meeting F-No. 43 classifications.

NB-4622.11(c)(3) discusses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. These requirements do not apply because the proposed alternative uses weld filler metals that do not require storage in heated ovens since weld GTAW bare filler metals will not pick up moisture from the atmosphere.

NB-4622.11(c)(4) discusses requirements for storage of covered electrodes during repair welding. These requirements do not apply because the proposed alternative utilizes bare weld filler metals, which do not require any special storage conditions to prevent the pick up of moisture from the atmosphere.

NB-4622.11(c)(5) requires preheat to a minimum temperature of 350 °F prior to repair welding, a maximum interpass temperature of 450 °F and that thermocouples and recording instruments shall be used to monitor the metal temperature during welding. The proposed ambient temperature temper bead alternative does not require an elevated temperature preheat and interpass will be limited to 350 °F. Because of the massive structure involved in the assembly, the absence of preheat and the complex configuration, thermocouples will not be used to monitor metal temperature.

NB-4622.11(c)(6) establishes requirements for shielded metal arc electrode diameters for the first, second, and subsequent layers of the repair weld and requires removal of the weld bead crown before deposition of the second layer. Because the proposed alternative uses the machine GTAW process, the requirement to remove the weld crown of the first layer is unnecessary and the proposed alternative does not include the requirement.

NB-4622.11(c)(7) requires the preheated area to be heated to 450 °F to 660 °F for four (4) hours after a minimum of 3/16 inch of weld metal has been deposited. The proposed alternative does not require this heat treatment because the use of the extremely low hydrogen GTAW temper bead procedure does not require the hydrogen bake-out.

NB-4622.11(c)(8) requires welding subsequent to the hydrogen bake out of NB-4622.11(c)(7) be done with a minimum preheat of 100 °F and maximum interpass temperature of 350 °F. The proposed alternative limits the interpass temperature to a maximum of 350 °F and requires the area to be welded be at least 50 °F prior to welding. These limitations have been demonstrated to be adequate for the production of sound welds.

NB-4622.11(d)(1) requires a liquid penetrant (PT) examination after the hydrogen bake out described in NB-4622.11(c)(7). The proposed alternative does not require the hydrogen bake-out because it is unnecessary for the low hydrogen GTAW temper bead welding process.

NB-4622.11(d)(2) requires PT and radiographic examinations (RT) of the repair welds after a minimum time of 48 hours at ambient temperature. Ultrasonic inspection (UT) is required if practical. The proposed alternative includes the requirement to inspect after a minimum of 48 hours at ambient temperature. Because the proposed repair welds are of a configuration that cannot be radiographed, final inspection will be by PT and UT.

NB-4622.11(d)(3) requires that all nondestructive examination (NDE) be in accordance with NB-5000. The proposed alternative will comply with NB-5000 except that the progressive PT inspection required by NB-5245 will not be done. In lieu of the progressive PT examination, the proposed alternative will use PT and ultrasonic examination of the final weld.

NB-4622.11(e) establishes the requirements for documentation of the weld repairs in accordance with NB-4130. The weld repair will be documented in accordance with NB-4130.

NB-4622.11(f) establishes requirements for the procedure qualification test plate relative to the P-No. and Group Number and the postweld heat treatment of the materials to be welded. The proposed alternative meets those requirements except that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair. In addition, the location of the V-notch for the Charpy test is more stringently controlled in the proposed alternative than in NB-4622.11(f).

NB-4622.11(g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs, which is particularly pertinent to the SMAW manual welding process. The proposed alternative involves a machine GTAW process and requires welding operators be qualified in accordance with ASME Section IX.

The use of a machine process eliminates concern about obstructions, which might interfere with the welder's abilities since these obstructions will have to be eliminated to accommodate the welding machine.

NB-4453.4 of Section III requires examination of the repair weld in accordance with the requirements for the original weld. The welds being made per the proposed alternatives will be partial penetration welds as described by NB-4244(d) and will meet the weld design requirements of NB-3352.4(d). For these partial penetration welds, paragraph NB-5245 requires a progressive surface examination at the lesser of 1/2 the maximum weld thickness or 1/2-inch, as well as a surface examination on the finished weld. For the proposed alternative, the repair weld will be examined by a PT and ultrasonic examination no sooner than 48 hours after the weld has cooled to ambient temperature in lieu of the progressive surface exams required by NB-5245.

2.4 Licensee Bases for Relief

The licensee has determined that it is impractical to perform the Code repair. Because of the risk of damage to the RVCH material properties or dimensions, it is not feasible to apply the PWHT requirements of paragraph NB-4622 of the 1989 ASME Section III Code to the RVCH. The alternative temper bead methods (IWA-4500 and NB-4622.9, NB4622.10 or NB-4622.11) offered by ASME Section III and ASME Section XI require elevated temperature preheat and post weld soaks that will result in added radiation dose to repair personnel.

The proposed alternative requires the use of an automatic or machine GTAW temper bead technique without the specified preheat or PWHT of the Construction Code. The proposed alternative will include the requirements of paragraphs 1.0 through 5.0 of Attachment 1 to the October 28, 2002, Relief Request, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique." The alternative will be used to make welds joining P-No. 3, RVCH material to P-No. 43 RVCH nozzle material using F-No. 43 filler material.

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.

The NB-4622 temper bead procedure requires a 350 °F preheat and a post weld soak at 450 °F to 660 °F for 4 hours for P-No. 3 materials. Typically, these kinds of restrictions are used to mitigate the effects of the solution of atomic hydrogen in ferritic materials prone to hydrogen embrittlement cracking. The susceptibility of ferritic steels is directly related to their ability to transform to martensite with appropriate heat treatment. The P-No. 3 material of the RVCH is able to produce martensite from the heating and cooling cycles associated with welding. However, the proposed alternative temper bead procedure utilizes a welding process that is inherently free of hydrogen. The GTAW process relies on bare welding filler metals with no flux to trap moisture. An inert gas

blanket positively shields the weld and surrounding material from the atmosphere and moisture it may contain. To further reduce the likelihood of any hydrogen evolution or absorption, the alternative procedure requires particular care to ensure the weld region is free of all sources of hydrogen. The GTAW process will be shielded with welding grade argon which typically produces porosity free welds. The gas would typically have no more than 1 ppm of hydrogen (H_2) and no more than 1 ppm of water vapor (H_2O). A typical argon flow rate would be about 15 to 50 cfh and would be adjusted to assure adequate shielding of the weld without creating a venturi affect that might draw oxygen or water vapor from the ambient atmosphere into the weld.

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 using thermocouples is unnecessary and would result in additional personnel dose associated with thermocouple placement and removal. Consequently, preheat temperature verification by use of a contact pyrometer on accessible areas of the closure head is sufficient. Also, in lieu of using thermocouples for interpass temperature measurements, calculations will be performed to show that the maximum interpass temperature will not be exceeded based on a maximum allowable low welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation will support the conclusion that, when 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 effect on the low alloy steel heat-affected zone (HAZ). The calculation will be based on a typical inter-bead time interval of five minutes. The five minute inter-bead interval is based on: 1) the time 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 property execute the temper bead technique.

A welding mockup on the full size Midland RVCH, which is similar to the ANO-1 RVCH, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the closure head during welding. Thermocouples were placed on the outside surface of the closure head within a 5-inch band -surrounding the RVCH nozzle. Three other thermocouples were placed on the closure head inside surface. One of the three thermocouples was placed 1½ inches from the RVCH nozzle penetration, on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5-inch band surrounding the RVCH nozzle; one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 150 °F throughout the 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 Midland RVCH 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.

Entergy has concluded that quality temper bead welds can be performed with a 50 °F minimum preheat and no post heat treatment based on ASME committee approval of Code Case N-638 and prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding. Entergy also concluded that the proposed alternative ambient temperature temper bead weld technique provides a technique for repairing flaws in the RVCH penetration to vessel head J-groove welds within 1/8-inch of the ferritic base metal that will produce sound and permanent repairs, and that the procedure is an alternative to Code requirements that will provide an acceptable level of quality and safety.

2.5 Evaluation

The 1989 Edition of ASME Section III, paragraph NB-4622.11, "Temper Bead Weld Repair to Dissimilar Metal Welds or Buttering," states that whenever PWHT is impractical or impossible, limited weld repairs to dissimilar metal welds of P-No. 1 and P-No. 3 material or weld filler metal A-No. 8 (Section IX, QW-442) or F-No. 43 (Section IX, QW-432) may be made without PWHT or after the final PWHT provided the requirements of the paragraphs NB-4622.11(a) through (g) are met.

The requirements of subarticles NB-4453 and 4622 of the 1989 Edition of ASME Section III are also applicable to the contemplated repairs. As an alternative to the PWHT time and temperature requirements of subarticle NB-4622, the requirements of "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," (Attachment 1 to ANO-R&R-003) will be used. Specifically, alternatives are being proposed for the following subparagraphs of ASME Section III, subarticle NB-4622:

NB-4622.1 through NB-4622.7 all establish various requirements for PWHT of welds. Since the repair welds will not be postweld heat treated, these paragraphs do not apply to the proposed alternative repair method.

NB-4622.8 establishes exemptions from PWHT for nozzle to component welds and branch connection to run piping welds. Subparagraph NB-4622.8(a) establishes criteria for exemption of PWHT for partial penetration welds. This is not applicable to the proposed repairs because the criteria involve buttering layers at least 1/4-inch thick, which will not exist for the welds in question. Subparagraph NB-4622.8(b) also does not apply because it discusses full penetration welds, and the welds in question are specially designed pressure boundary, structural welds.

NB-4622.9 establishes requirements for temper bead repairs to P-No. 1 and P-No. 3 materials and A-Nos. 1, 2, 10, or 11 filler metals. The subparagraph does not apply in this case because the proposed repairs will involve F-No. 43 filler metals.

NB-4622.10 establishes requirements for repair welding to cladding after PWHT. The subparagraph does not apply in this case because the proposed repair alternative does not involve repairs to cladding.

NB-4622.11 discusses temper bead weld repair to dissimilar metal welds or buttering and would apply to the proposed repairs as follows:

Subparagraph NB-4622.11(a) requires surface examination prior to repair in accordance with Article NB-5000 (NB-4622.11(d)(3)). The proposed alternative will include surface examination prior to repair consistent with Article NB-5000.

Subparagraph NB-4622.11(b) contains requirements for the maximum extent of repair. The proposed alternative includes the same limitations on the maximum extent of repair.

Subparagraph NB-4622.11(c) discusses the repair welding procedure and welder qualification in accordance with ASME Section IX and the additional requirements of Article NB-4000. The proposed alternative will satisfy these requirements. In addition, subparagraph NB-4622.11(c) requires the Welding Procedure Specification include the following requirements:

NB-4622.11(c)(1) requires the area to be welded be suitably prepared for welding in accordance with the written procedure to be used for the repair. The proposed alternative will satisfy this requirement.

NB-4622.11(c)(2) requires the use of the SMAW process with covered electrodes meeting either the A-No. 8 or F-No. 43 classifications. The proposed alternative utilizes GTAW with bare electrodes meeting the F-No. 43 classification. The use of a GTAW temper bead welding technique to avoid the need for postweld heat treatment is based on many acceptable Procedure qualification records (PQRs) and welding procedure specifications (WPSs) that have been utilized to perform numerous successful repairs, which indicate that the use of the ambient GTAW temper bead welding technique is an acceptable approach. From this data, it can be shown that adequate toughness can be achieved in base metal and HAZs with the use of a GTAW temper bead welding technique. The temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed. Therefore, the alternative temperature proposal is acceptable.

NB-4622.11(c)(3) discusses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. These requirements do not apply because the proposed alternative uses bare electrodes that do not require storage in heated ovens since bare electrodes will not pick up moisture from the atmosphere.

NB-4622.11(c)(4) discusses requirements for storage of covered electrodes during repair welding. These requirements do not apply because the proposed alternative utilizes bare electrodes, which do not require any special storage conditions to prevent the pickup of moisture from the atmosphere.

NB-4622.11(c)(5) requires preheat to a minimum temperature of 350 °F prior to repair welding. The proposed ambient temperature temper bead alternative does not require elevated temperature preheat. Data from welding procedure qualification tests using the machine GTAW ambient temperature temper bead welding shows that quality temper bead welds can be performed with a 50 °F minimum preheat and no post heat treatment.

NB-4622.11(c)(6) establishes requirements for electrode diameters for the first, second, and subsequent layers of the repair weld, and requires removal of the weld bead crown before deposition of the second layer. The proposed alternative uses weld filler metal much smaller than the 3/32-, 1/8-, and 5/32-inch electrodes required by sub-subparagraph NB-4622.11(c)(6). Also, the use of the ambient temperature automatic or machine GTAW temper bead process allows more precise control of heat input, bead placement, and bead size and contour than the manual SMAW process required by ASME Code, Sections III and XI. The very precise control over these factors afforded by the process provides more effective tempering and eliminates the need to grind or machine the first layer of the repair.

NB-4622.11(c)(7) requires the preheated area to be heated from 450 °F to 660 °F for a minimum period of 4 hours. The proposed alternative does not require this heat treatment because the use of the extremely low hydrogen GTAW temper bead procedure does not require the hydrogen bake-out.

NB-4622.11(c)(8) requires welding subsequent to the hydrogen bake-out of subparagraph NB-4622.11(c)(7) be done with a minimum preheat of 100 °F and maximum interpass temperature of 350 °F. The proposed alternative limits the interpass temperature to 350 °F and requires the area to be welded be at least 50 °F prior to welding. These limitations are adequate since the F-43 filler metal is not subject to hydrogen embrittlement and subsequent weld layers are not being deposited over a ferritic metal layer.

NB-4622.11(d)(1) requires a PT examination after the hydrogen bake-out described in subparagraph NB-4622.11(c)(7). The proposed alternative does not require the hydrogen bake-out because the very low hydrogen ambient GTAW temper bead welding process makes it unnecessary. A PT examination will be performed as a post-weld examination.

NB-4622.11(d)(2) requires PT and RT of the repair welds after a minimum of 48 hours at ambient temperature. UT is required, if practical. NB-4453.4 of ASME Section III requires examination of the repair weld in accordance with the requirements for the original weld, which requires a progressive surface examination at the lesser of ½ the maximum weld thickness or ½ inch, as well as surface examination on the finished weld. The proposed alternative includes the requirement to inspect after a minimum of 48 hours at ambient temperature. The geometry of the RVCH and the orientation of the inner bore of the RVCH nozzles make effective RT impractical. The thickness of the reactor pressure vessel head limits the sensitivity of the detection of defects in the new pressure

boundary weld. The density changes between the base and weld metal, and residual radiation from the base metal would render the film image inconclusive. Due to the high area dose which would cause fogging of the film and changing radius of the pressure vessel head which would cause geometric unsharpness condition, the staff concludes RT is impractical for this type of repair. Therefore, examinations by the ultrasonic method will be used in lieu of examinations by the radiographic method defined by IWA-4533 and progressive surface examination required NB-4453.4. The effectiveness of the UT was demonstrated on a mockup temper bead weld involving the same material as will be used for this repair.

NB-4622.11(d)(3) requires that all nondestructive examination be in accordance with NB-5000. The proposed alternative will comply with NB-5000, except that the progressive liquid penetrant inspection required by NB-5245 will not be done. In lieu of the progressive liquid penetrant examination, the proposed alternative will use liquid penetrant and ultrasonic examination of the final weld (see NB-4622.11(d)(2) above).

NB-4622.11(e) establishes the requirements for documentation of the weld repairs in accordance with subarticle NB-4130. The proposed alternative will comply with that requirement.

NB-4622.11(f) establishes requirements for the procedure qualification test plate. The proposed alternative complies with those requirements, except that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair. These requirements are more conservative than the NB-4622.11(f) requirements. In addition, the location of the V-notch for the Charpy test is more stringently controlled in the proposed alternative than in subarticle NB-4622.11(f).

NB-4622.11(g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs, which is particularly pertinent to the SMAW manual welding process. The proposed alternative involves a machine GTAW process and requires welding operators be qualified in accordance with ASME Section IX. The use of a machine process eliminates concern about obstructions that might interfere with the welder's abilities, since these obstructions will have to be eliminated to accommodate the welding machine.

The use of a GTAW temper bead welding technique to avoid the need for postweld heat treatment is based on research that has been performed by Electric Power Research Institute and other organizations. The research demonstrates that carefully controlled heat input and bead placement allow subsequent welding passes to relieve stress and temper the HAZ of the base material and preceding weld passes. Data presented in the report show the results of procedure qualifications performed with 300 °F preheats and 500 °F preheats, as well as with no preheat and postheat. From that data, it is clear that equivalent toughness is achieved in base metal and HAZs in both cases. The temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed. Many acceptable PQRs and WPSs

presently exist and have been utilized to perform numerous successful repairs. The use of the automatic or machine GTAW process for temper bead welding allows more precise control of heat input, bead placement, and bead size and contour than the manual SMAW process required by subarticle NB-4622. The very precise control over these factors afforded by the alternative provides more effective tempering and eliminates the need to grind or machine the first layer of the repair.

2.6 Conclusion

The staff concludes that the licensee's proposed alternative to use ambient temperature temperbead welding for repairing flaws in the RVCH nozzle penetration welds as discussed in Relief Request No. ANO1-R&R-003, Rev. 0 provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the proposed alternative for use at ANO-1. The alternative is authorized for the third 10-year ISI interval through the end of the refueling outage scheduled for the fall of 2005.

All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

3.0 RELIEF REQUEST NO. ANO1-R&R-004, REVISION 0

3.1 Component for Which Relief is Requested

Reactor Pressure Vessel Closure Head (RVCH) Nozzles

3.2 Code Requirement for Which Relief is Requested

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.

Pursuant to 10 CFR 50.55a(g)(5)(iii), relief is requested from ASME Section XI, IWA-3300(b), IWB-3142.4 and IWB-3420, which require flaw characterization.

Subarticle IWA-3300 contains criteria for characterizing flaws. None of the nondestructive evaluation techniques that can be performed on the remnant of the J-groove weld that will be left on the RVCH can be used to characterize flaws in accordance with

any of the paragraphs or subparagraphs of IWA-3300. In lieu of those requirements, a conservative worst case flaw shall be assumed to exist and appropriate fatigue analyses will be performed based on that flaw.

Subsubparagraph IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subject to successive examination during the next three inspection periods. Analytical evaluation of the worst case flaw referred to above will be performed to demonstrate the acceptability of continued operation. However, because of the impracticality of performing any subsequent inspection that would be able to characterize any remaining flaw, successive examination will not be performed. In any event, RVCH replacement is planned for refuel outage 1R19 in fall 2005, which will occur before the end of the next inspection period, obviating the need for successive inspections of the J-weld remnant.

Paragraph IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300. As previously stated, characterization in accordance with those rules is impractical. As an alternative, a conservative, worst case flaw will be assumed to exist and will be evaluated to establish the minimum remaining service life of the RVCH.

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

3.3 Licensee's Proposed Alternative

In lieu of the requirements of IWA-3300, the licensee proposes the following alternative:

> The planned repair for the subject RVCH nozzles does not include removal of any 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 as required by IWA-3300. In lieu of fully characterizing the existing cracks, Entergy will use worst-case assumptions to conservatively estimate the crack extent and orientation. The postulated crack extent and orientation will 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 will be completed to justify this welding solidification anomaly.

3.4 Licensee's Basis for Relief

The licensee stated that the inspections of the RVCH during refueling outage 17 may identify conditions that indicate a need to repair flaws discovered in the RVCH penetrations. A remote, semi-automated repair method will be used for each of the nozzles requiring repair. Using a remote tool from above the RVCH, each of the nozzles needing repair will first receive a roll expansion into the RVCH base material to ensure that the nozzle will not move during the subsequent repair operations. Second, a semi-automated machining tool from underneath the RVCH 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 RVCH nozzles. Third, a semi-automated weld tool, utilizing the machine 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 RVCH base material. The original J-groove partial penetration welds would be left in place to reduce radiation dose to repair personnel. These welds will no longer function as pressure boundary RVCH nozzle to RVCH welds. However, the possible existence of cracks in these welds mandates that the flaw growth potential be evaluated.

The licensee's position is that the original nozzle to RVCH weld configuration is extremely difficult to UT due to the compound curvature of the head and radius. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable confidence from the inner surface of the head. The licensee indicated that presently, the technology does not exist to characterize flaw geometries that may exist in the J-groove weld. Not only is the configuration not conducive to UT but the dissimilar metal interface between the Ni-Cr-Fe weld and the low alloy steel RVCH increases the difficulty of UT. Similarly, impediments to examination from the outer surface of the RVCH exist due to proximity of adjacent nozzle penetrations. The licensee proposes to accept these flaws by analysis of the worst case that might exist in the J-groove weld. Based on the worst case condition analysis, the licensee proposes that no future examinations be performed of the J-groove flaws.

For analysis purposes, the licensee assumed that flaw(s) may exist in the J-groove weld from the weld surface to the RVCH base metal interface. Based on extensive industry experience, the licensee indicated that there are no known cases where flaws initiating in an Alloy 82/182 weld have propagated into the ferritic base metal.

The licensee indicated a fracture mechanics evaluation would be performed to determine if the degraded J-groove weld metal 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 would be axially, or radially with respect to the nozzle. The licensee postulated that a radial crack in the Alloy 182 weld metal would propagate due to primary water stress corrosion cracking (PWSCC), through the weld and butter, to the interface with the low alloy RVCH and

that it would blunt and arrest at the butter-to-head interface. The licensee indicated that ductile crack growth in the Alloy 182 metal 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 RVCH metal are low, it will be assumed that a small flaw could initiate in the low alloy steel metal and grow by fatigue. The licensee postulates that a small flaw in the RVCH 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 RVCH by fatigue crack growth, under cyclic loading conditions associated with heatup and cooldown and other applicable transients.

The licensee stated that residual stresses will not be included in the flaw evaluation since it was demonstrated by analysis that these stresses are compressive in the low alloy steel base metal. The licensee indicated that 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 would be performed for a postulated radial corner crack on the RVCH penetration, where stresses are the highest and the radial distance from the inside corner to the low alloy steel base metal is the greatest. Fatigue crack growth calculated for the remaining operational life should be small and the final flaw size will be shown to meet the fracture toughness requirements of the ASME Code using an upper shelf value of 200ksi√in for ferritic metals.

The new pressure boundary weld for the nozzle remnant to the RVCH would also be analyzed for the propagation of potential flaws. This is the weld to the remnant of the nozzle after machining the bottom portion of the nozzle from the original J-groove weld. One analysis used a three dimensional model of a control rod drive mechanism (CRDM) nozzle located at the most severe hillside orientation. The analytical model would include the RPV head, CRDM nozzle, proposed new weld, and remnant portions of the original J-groove welds. The model is analyzed for thermal transient conditions pertinent to ANO-1 design specifications. The resulting maximum thermal gradients will be applied to the model along the coincident internal pressure values. A computer program will then calculate the stresses throughout the model (which includes the new welds). The calculated stress values are then compared to the ASME Code, Section III, NB-3000 criteria for design conditions (normal, operating and upset conditions) and emergency conditions (faulted and testing conditions).

3.5 Evaluation

The repair plan consists of partially machining out the CRDM nozzle through the section of the J-groove weld which attaches the nozzle to the RVCH, up to approximately mid-wall. At mid-wall, the remaining portion of the nozzle is welded and acts as the pressure retaining boundary. This repair action changes the category of the remnant J-groove weld from Examination Category B-O, Pressure Retaining Welds in Control Rod Housings to a non-pressure retaining weld, which is part of the base metal thickness.

The newly deposited repair weld is now treated as the pressure retaining weld and examined as Examination Category B-O under the ISI program.

The licensee's position is that the original CRDM nozzle to RVCH weld configuration is extremely difficult to UT due to the compound curvature of the head and fillet radius. These conditions preclude ultrasonic coupling from the RVCH and control of sound beam in order to perform flaw sizing with reasonable confidence in measuring the flaw dimension from the inner surface of the head. The licensee indicated that the technology does not exist to characterize flaw geometries that may exist in the J-groove weld. Another issue is the dissimilar metal interface between the Ni-Cr-Fe weld and the low alloy steel closure head which increases the difficulty of UT. Similarly, impediments to examination from the outer surface of the RVCH exist due to proximity of adjacent nozzle penetrations. Based on these physical limitations, the licensee went on to state that the inability to characterize the flaws will continue in the foreseeable future, making subsequent UT examinations of this region ineffective.

The staff finds that UT of any flaws in the J-groove weld region is ineffective and impractical due to the configuration. The angle of incidence from the outer surface of the closure head base material does not permit perpendicular interrogation by ultrasonic shear wave techniques of circumferentially oriented flaws and the physical proximity of the nozzle does not allow for longitudinal scrutiny of the area of interest. If examination of the J-groove weld were to be attempted from the inner diameter of the head, the cladding provides an acoustic interface which severely limits a confident examination of the weld material. Radiography of the area is also ineffective due to orientation of circumferentially oriented flaws being perpendicular to gamma and x-rays. In addition, surface examinations will not provide any useful volumetric information.

IWA-3300(a) of the ASME Code states that flaws detected by the preservice and inservice examinations shall be sized by the bounding rectangle or square for the purpose of description and dimensioning. IWA-3300(b) of the ASME Code states that flaws shall be characterized in accordance with IWA-3310 through IWA-3390 as applicable. IWB-3132.4(a) of the ASME Code states that components whose volumetric surface examinations reveal flaws that exceed the acceptance standards listed in Table IWB-3410-1 shall be acceptable for service without the flaw removal, repair, or replacement if an analytical evaluation, as described in IWB-3600, meets the acceptance criteria of IWB-3600.

The licensee performed flaw evaluations of ANO-1 CRDM postulated J-groove weld flaws, noted in supplemental letters dated November 26 and December 16, 2002. In the analyses, the licensee assessed the suitability of leaving degraded J-groove weld material in the RVCH following the repair of a CRDM nozzle by the inside diameter (ID) temper bead weld procedure. The analysis used the worst case that might exist in the J-groove. The licensee assumed that crack growth was limited to the Alloy 600 J-groove weld. The blunting of cracks at the carbon steel vessel-to-nozzle is supported by plant experience. The outermost nozzle locations are considered the most highly stressed locations on the head. Based on an evaluation of fatigue crack growth into the low alloy

steel head and considering the ASME Section XI requirements for fracture toughness, the licensee concluded that a postulated worst case crack in the Alloy 600 J-groove weld would be acceptable for 25 years of operation.

The NRC staff reviewed the fracture mechanics evaluation submitted in supplemental letters dated November 26 and December 16, 2002. The NRC staff found that the methodology used by the licensee to determine flaw geometry, fracture toughness for crack arrest, fatigue crack growth in primary water environment, and the overall fracture mechanics methodology was consistent with ASME Section XI requirements. The NRC staff concludes that the analysis assuming a worst case flaw remains in the "as left" J-groove weld provides reasonable assurance of structural integrity of the RVCH and is, therefore, acceptable.

Based on industry experience, the remaining flaws (if any are present) in the J-groove weld (which is no longer a pressure retaining weld) would arrest at the junction of the clad/ferritic metal interface. The licensee has analyzed the flaw as acceptable for continued service based on the flaw growing to the clad/ferritic junction and blunting. The NRC staff concludes that successive inspections of the "as-left" J-groove weld would not provide meaningful information related to the characterizing of the flaws due to the impracticality of the examination as described above. In addition, the licensee plans to replace the RVCH during the 1R19 refueling outage scheduled for the fall of 2005.

The licensee performed analyses of the CRDM nozzle temper bead weld repair with a postulated anomaly. The analyses were submitted in supplemental letters dated November 26 and December 16, 2002. The term weld anomaly is applied to the unusual solidification patterns that may result along the low alloy steel/Alloy 600/Filler Metal 52 interface of the repair weld. The licensee concluded that the analysis demonstrate that the 0.1 inch weld anomaly is acceptable for a 25 year design life of the CRDM nozzle ID temper bead weld repair. The fracture toughness margins have been demonstrated for each of the two flaw propagation paths considered in the analysis. The margins on limit load for the normal/upset conditions and emergency/faulted conditions were also found to be acceptable.

The licensee's submittal also discussed a Framatome ANP evaluation which has determined the amount of time needed for a crack to grow 75 percent through-wall in the Alloy 600 nozzle material above the repair weld. The evaluation considered RVCH nozzles both in the as-repaired condition and following abrasive water jet (AWJ) remediation. The evaluation is for initiation and crack growth due to PWSCC. If AWJ mitigation is used, the estimated corrosion time to breach the AWJ compressive residual stress layer and the estimated crack growth time to 75 percent through wall would yield 14.6 effective full power years estimated service life.

The licensee will volumetrically examine these repair welds during the next refueling outage (1R18) for comparison with the baseline data collected after their installation. Additionally, the licensee plans to replace the RVCH during the 1R19 refueling outage scheduled for the fall of 2005.

The NRC staff concludes that requiring the licensee to comply with the Construction Code repair and NDE requirements is impractical. The licensee's request and supporting information on the impracticality of characterizing flaws in the remnant J-groove welds and analyses bounding postulated flaws provides assurance of structural integrity of the repair.

3.6 Conclusion

Based on the discussion above for Relief Request No. ANO1-R&R-004, Revision 0, the staff has concluded that the proposal to leave cracks in the nonpressure boundary portion of the remaining J-groove partial penetration weld and to evaluate crack growth using the appropriate ASME Section XI criteria for a worst case crack growth scenario is acceptable. Also, based on the above discussion, the staff has concluded that flaws left in the J-groove penetration weld are impractical to examine. However, if a triple-point anomaly exists following the new pressure boundary weld repair and the licensee determines that the anomaly is acceptable for continued service, the licensee will volumetrically examine these welds during the next refueling outage for comparison with the baseline data collected after their installation to ensure weld integrity. Further, based on the licensee's anticipated replacement of the RVCH in the fall of 2005, the actions of the licensee provides reasonable assurance of structural integrity for the RVCH repair. The staff concludes that granting relief pursuant to 10 CFR 50.55a(g)(6)(i) is authorized by law and will not endanger life or property or the common defense and security, and is otherwise in the public interest giving due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility. The alternative is authorized for the ANO-1 third 10-year ISI interval through the end of the refueling outage scheduled for the fall of 2005. The granting of relief request to 10 CFR 50.55a(g)(6)(i) is authorized by law and will not endangered life or property or the common defense and security, and is otherwise in the public interest giving due consideration to the burden upon the license that could result if the requirements were imposed on the facility.

All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternatives for Relief Request No. ANO1-R&R-003 provides an acceptable level of quality and safety, and is authorized pursuant to 10 CFR 50.55a(a)(3)(i) during the third 10 year interval through the fall 2005 refueling outage. Further, the staff concludes that it is impractical to comply with the Code requirements for the repairs, and that ANO1-R&R-004 is granted pursuant to 10 CFR 50.55a(g)(6)(i) for the third 10-year interval through the fall 2005 refueling outage.

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