Mr. Dale E. Young, Vice President January 6, 2004
Crystal River Nuclear Plant (NA1B)
ATTN: Supervisor, Licensing & Regulatory Programs
15760 W. Power Line Street
Crystal River, Florida 34428-6708

SUBJECT: CRYSTAL RIVER UNIT 3 - SAFETY EVALUATION OF RELIEF REQUESTS 03-001-RR AND 03-0002-RR CONCERNING ALTERNATIVE REPAIR METHOD AND FLAW CHARACTERIZATION FOR PRESSURIZER INSTRUMENT NOZZLE PENETRATIONS (TAC NOS. MC0947 AND MC0963)

Dear Mr. Young:

In a letter dated October 5, 2003, as supplemented by letter dated October 11, 2003, Florida Power Corporation (FPC, or the licensee, also doing business as Progress Energy Florida, Inc.) requested that the Nuclear Regulatory Commission (NRC) approve relief requests 03-0001-RR, Revision 0, and 03-0002-RR, Revision 0 in order to perform repairs on pressurizer nozzle penetrations that have developed through-wall leakage at the Crystal River Nuclear Plant, Unit 3. The reliefs were requested pursuant to 10 CFR 50.55a(a)(3)(i) as an acceptable alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, seeking relief from certain requirements of the ASME Code, Section XI, 1989 Edition with no Addenda. Specifically, in relief 03-0001-RR, FPC requested to perform a portion of the pressurizer nozzle repairs with a remotely operated welding tool using the Gas Tungsten Arc Welding process and ambient temper bead method with 50 degree Fahrenheit minimum preheat temperature and no post-weld treatment. In relief 03-0002-RR, FPC requested to use worst-case assumptions to conservatively estimate the crack extent and orientation.

The relief is requested for repair of pressurizer nozzles during Refueling Outage 13 at Crystal River, Unit 3. Based on the enclosed Safety Evaluation (SE), the NRC staff finds Relief Requests 03-0001-RR, Revision 0, and 03-0002-RR, Revision 0, acceptable. Based on initial detailed review of the information provided by FPC, the NRC granted verbal approval of the relief requests on October 30, 2003.

Sincerely,

/RA by M L Marshall for/

Allen G. Howe, Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-302

Enclosure: Safety Evaluation

cc w/encl: See next page

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The bases for the NRC staff's conclusions are contained in the enclosed SE. If you have any questions regarding this issue, please feel free to contact Ms. Brenda Mozafari at 301-415-2020.

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Allen G. Howe, Chief, Section 2
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INSERVICE INSPECTION PROGRAM

RELIEF REQUESTS 03-0001-RR, REVISION 0

AND 03-0002-RR, REVISION 0

CRYSTAL RIVER NUCLEAR PLANT UNIT 3

FLORIDA POWER CORPORATION

DOCKET NUMBER 50-302

1.0 INTRODUCTION

By letter dated October 5, 2003, as supplemented by letter dated October 11, 2003, pursuant to Title 10 to the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), Florida Power Corporation (FPC, or the licensee, also doing business as Progress Energy Florida, Inc.) submitted two requests for relief to be implemented during the ongoing refueling outage 13 at its Crystal River Nuclear Plant, Unit 3 (CR3). In relief request 03-0001-RR, the licensee sought relief from the requirements of Article IWA-4500 of the American Society of Mechanical Engineers Code (ASME Code), Section XI, 1989 Edition to perform weld repairs on pressurizer nozzle penetrations that have been determined to have through-wall leakage. The licensee proposed to perform the repair utilizing a half-nozzle repair method with a remotely operated weld tool, using the machine Gas Tungsten Arc Welding (GTAW) process and an ambient temperature temper bead method with 50°F minimum preheat temperature and no post-weld heat treatment (PWHT) as described in Code Case N-638. Code Case N-638 has been approved for use by the NRC. The Code case provides relief to allow the use of machine GTAW with ambient temperature preheat and no PWHT when draining the vessel is impractical. The methodology of N-638 will be applied due to dose considerations, even though the vessel can be drained. This philosophy is in accordance with the CR3 As Low As Reasonably Achievable (ALARA) program. In relief request 03-0002-RR, the licensee sought relief from the requirements of paragraph IWA-4310 of the ASME Code, Section XI, to determine the size of the flaws left in the J-groove weld of the nozzle and instead proposed to use the worst-case assumptions to conservatively estimate the size and orientation of flaws.

2.0 REGULATORY EVALUATION

10 CFR 50.55a(g) specifies that inservice inspection (ISI) of nuclear power plant components shall be performed in accordance with the requirements of the ASME Code, Section XI, except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). 10 CFR 50.55a(a)(3) states that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (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.

In accordance with 10 CFR 50.55a(f)(4)(ii), licensees are required to comply with the requirements of the latest edition and addenda of the ASME Code incorporated by reference in the regulations 12 months prior to the start of subsequent 120-month (ISI) program intervals. Licensees whose ISI program reaches its 120-month (10-year) interval after November 22, 2000, are required to implement the 1995 Edition with the 1996 Addenda of the ASME *Code for Operation and Maintenance of Nuclear Power Plants* (ASME OM Code).

ASME Code cases approved by the NRC provide an acceptable voluntary alternative to the mandatory ASME Code provisions. Title 10 of CFR 50.55a was amended to incorporate Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," by reference and states the requirements governing the use of Code cases. ASME Code Cases N-638 and N-416-2 have been approved for use as indicated in RG 1.147.

10 CFR 50.55a(g)(5)(iii) states that if the licensee has determined that conformance with certain Code requirements is impractical for its facility, the licensee shall notify the Commission and submit, as specified in §50.4, information to support the determinations. The Code of record for the third 10-year ISI interval for Crystal River, Unit 3 is the 1989 Edition of the ASME Code, with no Addenda.

3.0 TECHNICAL EVALUATION

3.1 Relief Request 03-0001-RR, Revision 0

3.1.1 System/Components for Which Relief is Requested:

a) Name of component:

Pressurizer Level Instrument and Sampling nozzle penetrations. There are 6 level instrument penetrations and 1 sampling penetration in the shell of the Pressurizer.

b) Function:

The nozzles and penetration welds serve as the pressure boundary for the Pressurizer shell.

c) ASME Code Class:

The Pressurizer and instrument and sampling nozzle penetrations are ASME Class 1.

d) Category:

Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels; Item No. B4.13 for the modified penetrations and those original penetrations not modified.

Also Category B-P Items B15.20 and B15.21 [apply] to the original unmodified locations and modified locations at the new weld.

3.1.2 Current Code Requirement and Relief Request:

a) ASME B&PV [Boiler and Pressure Vessel] Code, Section XI 1989 Edition, IWA-4120(a) 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-4500 and IWB-4000 may be used for Class 1 components.

b) In accordance with 10 CFR 50.55a(a)(3)(i), Progress Energy Florida Inc. (PEF), Crystal River Unit 3 (CR3) is requesting relief from the following portion of ASME Section XI, IWA-4120(a) and its referenced IWA-4500 to perform Pressurizer nozzle penetration repairs:

> "If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4500 and IWB-4000 may be used for Class 1 components."

In lieu of performing the repair using the alternative welding techniques described in IWA-4500, CR3 is proposing to perform a portion of 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, as described in Code Case N-638. CR3 is requesting the use of the Code Case in its entirety, except for deviations as listed in Table 1, below. [*Table 1 is not included in this Safety Evaluation (SE) but was included in the licensee's submittal*]. The description of the proposed alternative is provided in the following section.

c) CR3 intends to use Code Case N-416-2 to perform a system leak test in lieu of a hydrostatic pressure test. Since this Code Case has been previously approved by the NRC, no Code relief is required. However, Code Case N-416-2 stipulates the use of the 1992 Editions of ASME Sections III and XI for fabrication and installation joint NDE [nondestructive examination] and the system leakage test. Consequently, CR3 has adopted the 1992 Editions of Sections III and XI for all aspects of the NDE and inspection associated with this replacement in lieu of the 1989 Code Edition referenced in the CR3 ASME Section XI Repair and Replacement Program.

d) CR3 has determined that the proposed alternative will provide an acceptable level of quality and safety, while allowing significant dose reductions.

3.1.3 Alternate Criteria for Acceptability:

CR3 plans to perform Pressurizer nozzle penetration repairs as follows:

1. Mechanical removal of a portion of the existing nozzle.
2. Application of a weld pad (or weld buildup) using F-No. 43 to the Pressurizer shell (P-No. 1, Grade 2) base material.

3. Machining the weld pad to accept the new nozzle (P-No. 43).
4. Installing the replacement nozzle by using conventional manual gas tungsten arc welding (GTAW) and a “J” groove partial penetration weld.

The proposed alternative to the applicable portion of ASME, Section XI involves the use of the ambient temperature temper bead repair described in Code Case N-638. This methodology is proposed to be used only for the weld pad application, Step 2 of the repair process. Code Case N-638 was approved for use in Regulatory Guide 1.147, Revision 13, (June 2003).

[In its supplemental information letter dated October 11, 2003, FPC also stated that measurement of preheat and interpass temperature will be accomplished as follows: Preheat and interpass temperatures for the weld pad will be measured using a contact pyrometer. Interpass temperature will be monitored for the first three layers of each repair. On the first repair location, the interpass temperature measurements will be taken every three to five passes. Subsequent repair locations will monitor interpass temperature every six to ten passes.]

Table 1 was prepared as a means to readily describe those areas where the proposed methodology deviates from the requirements of the original construction code, ASME XI, or the code case. [*Table 1 is not included in this SE but was included in the licensee’s submittal*].

3.1.4 <u>Basis for Relief</u>:

The basis for the relief request is that the use of an ambient temperature temper bead welding process provides an equivalent acceptable level of quality and safety when compared to the temper bead welding process in ASME, Sections XI and III, while offering substantial savings in accumulated radiation dose. In support of this conclusion, the process is described below, followed by technical justification for the differences between the two techniques, as well as the expected dose savings.

1. Description of the process

Figure 1 provides a general overview of the configuration. [Figure 1 is not included in this SE but was included in the licensee’s submittal].

a) Visual inspections for leakage/boric acid deposits of Pressurizer Instrument and Sampling nozzle penetrations are being conducted during Refueling Outage 13 (R13). Pressurizer nozzles that have been determined to have through-wall leakage will be repaired. Remote machine processes similar to those used previously at CR3, South Texas Project, Arkansas Nuclear 1, Unit 1 (ANO), Millstone and other facilities are planned.

b) The existing piping will be cut away from the nozzle and the nozzle cut close to the Pressurizer shell. The nozzle will then be ground flush with the Pressurizer shell and the area around the nozzle will be prepared for the application of the weld pad by grinding smooth and performing a surface examination (PT or MT) and ultrasonic examination of the area to be welded and the 5 inch wide band surrounding the weld area.

c) A weld pad is applied to the surface of the Pressurizer shell using the ambient temperature temper bead weld process and GTAW method as described in Code Case N-638. The weld pad is applied as a weld buildup centered on the existing nozzle opening.

d) The weld pad is prepared suitable for non-destructive examination (NDE). The pad and its HAZ [heat-affected zone] below the pad are volumetrically examined (UT) to the extent practical. The weld pad and a 5 inch wide band of the Pressurizer shell surrounding the weld pad are also surface examined (PT or MT). The examinations and acceptance criteria are in accordance with ASME III, 1992 Edition, no Addenda, NB-5000.

   Ultrasonic examination, before and after welding, of the full parent material thickness beneath the weld pad, to the extent practical, is performed to discern laminar type indications therein. Laminar type indications observed will be recorded and evaluated to assure the structural integrity of the modification configuration is not adversely affected.

e) The center of the weld pad is ground or machined to re-establish a free path into the Pressurizer penetration. The outer portion of the remaining existing nozzle is removed by machining into the Pressurizer shell. The weld pad is prepared to accept the new nozzle using a "J" groove partial penetration weld.

f) The new nozzle is inserted and welded using conventional welding and NDE techniques (manual GTAW and progressive PT). Note that this weld is in full ASME construction code compliance and relief from code requirements is not required.

2. Justification

   a) As low as reasonably achievable (ALARA)

      Experience gained from the performance of similar repairs/modifications at other plants indicate that remote automated repair methods reduce the radiation dose to repair personnel and still provide acceptable levels of quality and safety. CR3 is aware that ASME is in the process of revising Code Case N-638 to reflect the acceptability of this method for ALARA considerations as well as the inability to drain the vessel. Since CR3 recognizes the importance of ALARA principles, this remote repair method has been developed for the possibility of leaking nozzles at CR3.

      This approach for repair of leaking Pressurizer nozzles will significantly reduce radiation dose to repair personnel while still maintaining acceptable levels of quality and safety. CR3 estimates the dose accumulated providing access, installing heating pads and performing the preheat and post weld heat treatment required by the construction code would be between 4.8 to 7.2 REM per nozzle repair. Assuming that only one nozzle requires repair, use of the ambient temperature temper bead process results in a reduction of 4.8 to 7.2 REM for the repair.

b) Procedure Qualification

Results of procedure qualification work undertaken to date on low alloy steel base material indicate that the ambient temperature temper bead process produces sound and tough welds. Industry experience also indicates that the GTAW temper bead process has the capability of producing acceptable welds on P-No. 3 Group No. 3 as well as P-No. 1 Group No. 2 ferric steel base materials. Framatome ANP (FANP) has qualified the welding process and procedures for this specific application in accordance with code and code case requirements prior to its use at CR3.

To ensure the acceptability of the process for the current application, FANP has reviewed prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding on low alloy steel P-No. 3 Group No. 3 base materials in accordance with Code Case N-638. The qualifications were performed at room temperature under similar conditions as the current application. The results of this procedure qualification work indicate that the process produces sound and tough welds.

The existing qualification work can be compared to the current process. Specifically, the existing Code Case N-638 qualifications were performed on P-No. 3 Group No. 3 base materials, which have a higher hardenability and propensity for hydrogen embrittlement than the Pressurizer shell base material (P-No. 1 Group No. 2). These qualifications used the same filler material (Alloy 52 AWS Class ERNiCrFe-7) with similar low heat input controls as will be used in this application. These qualifications did not include a post weld heat soak. The successful qualification of the ambient temperature temper bead welding process demonstrates that the proposed alternative provides an acceptable level of quality and safety.

As previously noted, FANP has successfully performed a machine GTAW procedure qualification using the same test assembly base material, SA-516 Gr. 70, P-No.1 Group No. 2 base material, as the Pressurizer shell and the same weld filler metal Alloy 52 AWS Class ERNiCrFe-7, F-No. 43 as will be used in the field.

c) Weld Quality

The proposed alternative repair technique has been demonstrated as an acceptable method for performing Pressurizer nozzle 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 also been previously approved by the NRC as having an acceptable level of quality and safety and used successfully at several utilities (Three Mile Island, CR3, Millstone, St. Lucie, ANO, South Texas Project, and others). This Code Case has been approved in Regulatory Guide 1.147, Revision 13. This approval indicates that the methodology is capable of producing quality in-situ repairs.

As documented in EPRI Report GC-111050, research shows that carefully controlled heat input and bead placement allow subsequent welding passes to relieve stress and temper the HAZ of the base material. The use of the machine GTAW temper bead process will allow precise control of heat input, bead placement, and bead size and contour as compared to the SMAW process. The very precise control over these factors afforded by the machine GTAW process provides effective tempering of the HAZ.

The machine GTAW temper bead process uses a welding process that is inherently free of hydrogen. The GTAW process relies on bare welding electrodes and bare wire filler metal with no flux to trap moisture. An inert gas blanket provides shielding for the weld and surrounding metal, which protects the region during welding from the atmosphere and the moisture it may contain and typically produces porosity free welds. In accordance with the weld procedure qualification, welding grade argon is used for the inert gas blanket. To further reduce the likelihood of any hydrogen evolution or absorption, specific controls will be used to ensure the welding electrodes, filler metal and weld region are free of all sources of hydrogen will be used. Argon flow rates are 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.

Typically preheat and post weld heat treatment 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. 1 Group No. 2 material of the Pressurizer is able to produce martensite from heating and cooling cycles associated with welding, however it is much less susceptible to martensite formation than P-No. 3 Group No. 3 base material.

d) Maximum Preheat & Interpass Temperature Measurement

Due to the location of the repair and area radiation dose rate, the placement of thermocouples for monitoring weld interpass temperature is determined to be not beneficial based on dose savings. Therefore, thermocouples are not planned for use to monitor interpass temperature during welding. The location of the Pressurizer ensures that its temperature will be above 50°F prior to welding. In lieu of using thermocouples, calculations show that 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 carbon steel HAZ. The interpass temperatures will be verified during the Procedure Qualification.

[In its letter of October 11, 2003, FPC also stated that measurement of preheat and interpass temperature will be accomplished as follows: Preheat and interpass temperatures for the weld pad will be measured using a contact pyrometer. Interpass temperature will be monitored for the first three layers of each repair. On the first repair location, the interpass temperature measurements will be taken every three to five passes. Subsequent repair locations will monitor interpass temperature every six to ten passes.]

e) Examination

All examinations will be performed in accordance with ASME III, 1992 Edition, NB-5000 as specified in Code Case N-416-2, using personnel qualified in accordance with IWA-2300 and/or NB-5500.

The area to be welded, plus a 5 inch surrounding band, will be surface examined (PT or MT) both prior to and following welding. All post weld exams will be performed after the required 48 hour hold time. The entire volume of the weld pad, to the extent practical, will be scanned from the face of the pad, using examination angles of 0°, 45° RL, 60° RL and an OD creeping wave. The examination volume shall include the weld-deposited material and the ferritic vessel HAZ.

Ultrasonic examination, before and after welding, of the full parent material thickness beneath the weld pad, to the extent practical, will be performed to discern laminar type indications therein. Laminar type indications observed will be recorded and evaluated to assure the structural integrity of the modification configuration is not adversely affected.

Because this is a surface application of the temper bead process, there will be minimal impact to the volume of the Pressurizer shell in the area surrounding the weld. Since this weld is applied to the surface of the Pressurizer shell only, there is no additional useful information that can be gained by a volumetric examination of the area surrounding the weld. The weld and HAZ below will be post weld volumetrically examined to the extent possible. This reduction in the post welding inspection will provide additional dose reduction for this repair while still ensuring sound weld metal is deposited and that the process has not introduced flaws in the base material.

f) Corrosion

The automated repair method described above leaves an area of ferritic carbon steel at the outside diameter (OD) of the nozzle [inside diameter (ID) of the nozzle bore] exposed to the primary coolant. The effect of corrosion on the exposed area, including both reduction in Pressurizer wall thickness and primary coolant Iron (Fe) release rates, has been evaluated by Framatome FANP and concurred with by CR3 (CR3 Document M03-0030, Rev. 0). The analysis shows that the total corrosion is insignificant when compared to the thickness of the Pressurizer shell. It is also concluded that the total estimated Fe release is significantly less than the total Fe release from all other sources. CR3 has determined that the expected extremely low rate of material loss and Fe release rates will provide an acceptable level of safety.

g) Stresses

A stress analysis of the modified weld configuration has been performed (CR3 Document M03-0033, Rev. 0). The stress analysis demonstrates that the modified nozzle configuration complies with the criteria of NB-3000, ASME III, 1989 Edition, no Addenda, using design and service conditions applicable to the Pressurizer.

Therefore, based on the discussion above, CR3 has determined that the proposed alternative provides an acceptable level of quality and safety while reducing radiation exposure to as low as reasonably achievable.

3.1.5 Documentation:

The use of the Code Cases and this Relief Request shall be documented on the NIS-2 Form for the repair.

3.1.6 Implementation Schedule:

This relief request is being implemented during the Third Inservice Inspection Interval and it is only applicable to the repairs to the pressurizer level instrument and sampling nozzle penetrations.

3.1.7 Staff Evaluation

In relief request 03-0001-RR, the licensee sought relief from the requirements of Article IWA-4500 of the ASME Code Section XI, 1989 Edition to perform weld repairs on pressurizer nozzle penetrations that have been determined to have through-wall leakage. ASME B&PV Code, Section XI, 1989 Edition, IWA-4120(a) requires that weld repairs be made in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later Code Editions and Addenda of the Construction Code, or of ASME Code, Section III, may be used. If repair welding cannot be performed in accordance with these requirements, the applicable alternative requirements of IWA-4500 and IWB-4000 of ASME Code, Section XI may also be used for Class 1 components.

The licensee proposed to perform the repair utilizing a half-nozzle repair method with a remotely operated weld tool, using the machine Gas Tungsten Arc Welding (GTAW) process and the ambient temperature temper bead method with 50°F minimum preheat temperature and no PWHT, as described in Code Case N-638. Code Case N-638 has been approved for use by the NRC in Regulatory Guide 1.147, Revision 13. The licensee also proposed to use Code Case N-416-2 to perform a system leak test in lieu of a hydrostatic pressure test. Code Case N-416-2 has been also previously approved by the NRC. However, Code Case N-416-2 requires the use of the 1992 Editions of ASME Sections III and XI for fabrication, NDE, and system leakage tests. Consequently, CR3 has adopted the 1992 Editions of Sections III and XI for all aspects of the NDE and inspection associated with this weld repair in lieu of the 1989 Code Edition referenced in the CR3 ASME Section XI Repair and Replacement Program.

Code Case N-638 provides for the use of machine GTAW with ambient temperature preheat and no PWHT when draining the vessel is impractical for operational or radiological reasons. Although draining the CR3 pressurizer is not impractical (i.e., it can be drained), the methodology of N-638 can be applied to obtain a significant reduction in radiation dose for the reasons stated in Section 3.1.4.2.a of this SE. Therefore, the licensee has requested relief from the requirement in Code Case N-638 that the vessel not be drained. Code Case N-638 included the statement about not draining the vessel so that repairs could be made on reactor vessels not drained for operational or radiological reasons. However, it was not their intention to eliminate using this Code case on vessels that were drained. The deletion of the water backing is a conservatism because water on the backside of a weld is a hindrance to weld quality. It can lead to problems with a rapid quench and its deleterious effects on weld hardness. Water backing can also lead to problems with porosity in welds. Therefore, deletion of water backing will provide an acceptable level of quality and safety.

Paragraph IWA-4533(b) in ASME Section IX requires that preheating and interpass temperature be monitored using thermocouples and recording instruments. As an alternative to this Code requirement, FPC has stated that, "Measurement of preheat and interpass temperature will be accomplished as follows: Preheat and interpass temperatures for the weld pad will be measured using a contact pyrometer. Interpass temperature will be monitored for the first three layers of each repair. On the first repair location, the interpass temperature measurements will be taken every three to five passes. Subsequent repair locations will monitor interpass temperature every six to ten passes." Code Case N-638 requires that, for the welding of the pressurizer, the preheat temperature shall be 50°F (minimum) prior to depositing the first weld layer. For the first three layers, the interpass temperatures shall be at least 50°F but less than 150°F. The interpass temperature of each remaining layer shall be at least 50°F but less than 350°F prior to depositing the subsequent weld layers. The preheat temperature required for this welding is 50°F. This temperature is to be maintained on a weldment inside a building that normally is above this temperature. Therefore, preheat measurement by this alternate method is acceptable. The maximum interpass temperatures required for this welding (150°F for the first three layers, and a maximum interpass temperature of 350°F for the balance of welding), can easily be measured with this type of device. Also, the large mass of the pressurizer coupled with the low heat input GTAW process should help to ensure that the maximum interpass temperature will not be exceeded, and with the alternate temperature measurement methods a close control will be maintained on these temperatures. Therefore, this type of temperature measurement will provide an acceptable level of quality and safety.

To accomplish the repair, the licensee will utilize the half-nozzle repair method, which has been successfully employed in the past at other nuclear power plants. The repair is accomplished by removing the existing piping from the nozzle followed by cutting the nozzle close to the pressurizer shell. The nozzle will then be ground flush with the pressurizer shell, and the area around the nozzle will be prepared for the application of the weld pad by grinding the surface smooth. The area prepared for welding will be surface (PT or MT) and ultrasonically examined, which would include a 5-inch wide band surrounding the weld area. The weld pad will be applied to the surface of the pressurizer shell using the ambient temperature temper bead weld process and GTAW method as described in Code Case N-638. The weld pad made of Alloy 52 filler metal will be applied as a weld buildup centered on the existing nozzle opening, and the weld pad surface will be prepared for NDE. The pad and its HAZ below the pad will be volumetrically examined (UT) to the extent practical. The weld pad and a 5 inch wide band of the pressurizer shell surrounding the weld pad will be also surface examined (PT or MT). The surface and ultrasonic examinations and acceptance criteria will meet the requirements of article NB-5000 of ASME Code, Section III, 1992 Edition, with no Addenda. Therefore, the examinations are acceptable. In addition, ultrasonic examination, before and after welding, of the full parent material thickness beneath the weld pad will be performed to detect laminar type indications if present in the base metal. Laminar-type indications, if detected, will be recorded and evaluated to ensure that the structural integrity of the weld repair is not affected. This is acceptable because the ultrasonic examination will verify that weld buildup is not applied in close proximity to laminations and thus the structural integrity of the weld repair is ensured. The center of the weld pad will be ground or machined to re-establish a free path into the pressurizer penetration. The outer portion of the remaining existing nozzle will be removed by machining into the pressurizer shell. The weld pad will be prepared to accept the new nozzle using a "J" groove partial penetration Alloy 52 weld. The new nozzle made of Inconel 690 material will be inserted and welded using ASME Code-approved welding and NDE methods such as manual GTAW and progressive PT.

Based on the above, the NRC staff finds the licensee's proposed weld repair process acceptable for repair of pressurizer nozzles that have been found to have through-wall leakage. This is based on the fact that the repair process utilizes remotely operated weld tool, employing the machine GTAW temper bead method with 50°F minimum preheat temperature, and no PWHT as described in Code Case N-638. Code Case N-638 has been previously approved by the NRC. In addition, the NRC has previously approved the use of remote machine processes to do weld repairs that have been successfully accomplished at CR3, South Texas Project, Arkansas Nuclear One Unit 1, and Millstone nuclear power plants. As a result, the NRC staff concludes that the licensee has proposed an acceptable alternative to the requirements of IWA-4120(a) and IWA-4500 of the ASME Code, Section XI.

3.2 Relief Request 03-0002-RR, Revision 0

3.2.1 System/Components for Which Relief is Requested:

a) Name of component:

Pressurizer Level Instrument and Sampling nozzle penetrations. There are 6 level instrument penetrations and 1 sampling penetration in the shell of the Pressurizer.

b) Function:

The nozzles and penetration welds serve as the pressure boundary for the Pressurizer shell.

c) ASME Code Class:

The Pressurizer, and instrument and sampling nozzle penetrations are ASME Class 1.

d) Category:

Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels; Item No. B4.13 for the modified penetrations and those original penetrations not modified.

Also Category B-P Items B15.20 and B15.21 [apply] to the original unmodified locations and modified locations at the new weld.

3.2.2 Current Code Requirement and Relief Request:

CR3 intends to use Code Case N-416-2 to perform a system leak test in lieu of a hydrostatic pressure test. Since this Code Case has been previously approved by the NRC, no Code relief is required. However, Code Case N-416-2 stipulates the use of the 1992 Editions of ASME Sections III and XI for fabrication and installation joint NDE and the system leakage test. Consequently, CR3 has adopted the 1992 Editions of Sections III and XI for all aspects of the NDE and inspection associated with this replacement in lieu of the 1989 Code Edition referenced in the CR3 ASME Section XI Repair and Replacement Program.

In accordance with the provisions of ASME B&PV Code, Section XI 1989 Edition, IWA 4120(c), Progress Energy Florida Inc. (PEF), Crystal River Unit 3 (CR3) 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.” ASME Section XI, IWA-3300 requires characterization of flaws detected by inservice examination.

CR3 is requesting relief from ASME Section XI, IWA-3300. It is assumed that flaws in the original Pressurizer Instrument or Sampling nozzle to Pressurizer shell J-groove weld will not be removed. In lieu of fully characterizing the existing cracks, CR3 proposes to utilize worst-case assumptions to conservatively estimate the crack extent and orientation. CR3 has determined that the proposed alternative will provide an acceptable level of quality and safety, while allowing significant dose reductions.

3.2.3 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 Pressurizer nozzles does not include removal of any flaws assumed to be present 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. In addition, 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, CR3 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.

3.2.4 Basis for Relief:

Inspections of the Pressurizer Instrument and Sampling nozzle penetrations in response to potential RCS leakage, have discovered small amounts of RCS leakage emanating from the Pressurizer nozzle interface with the outside radius of the Pressurizer shell.

CR3 plans to perform Pressurizer nozzle penetration repairs as follows:

1. Mechanical removal of a portion of the existing nozzle.
2. Application of a weld pad or weld buildup (F-No. 43) to the Pressurizer shell (P-No 1, Group No. 2) base material.
3. Machining the weld pad to accept the new nozzle (P-No. 43).
4. Installing the replacement nozzle by using conventional manual gas tungsten arc welding (GTAW) and a “J”-groove partial penetration weld.

The existing nozzle(s) and weld(s) will no longer function as a Pressurizer vessel pressure boundary. However, the possible existence of cracks in these welds mandates that the potential for flaw growth 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 and the inaccessibility of the inside of the Pressurizer dictated that the inside weld and nozzle portion be left intact inside the Pressurizer.

The assumptions of IWB-3500 are that the cracks are fully characterized to be able to compare the calculated crack parameters to the acceptable parameters provided 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. Using worst case (maximum) assumptions with the geometry of the as-left weld, the postulated crack is assumed to begin at the intersection of the Pressurizer shell inner diameter surface and the Pressurizer nozzle penetration bore and propagate into the Pressurizer shell carbon steel. The depth and orientation are worst-case assumptions for cracks that may occur in the remaining J-groove partial penetration weld configuration. It is assumed that the “as-left” condition of the remaining J-groove weld includes degraded or cracked weld material.

A fracture mechanics evaluation has been performed (CR3 Document M03-0032, Revision 0). The analysis determines if a degraded J-groove weld material could remain 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 higher than the axial stresses, the preferential direction for cracking is axial, or radial relative to the nozzle. It is postulated that a radial crack in the Alloy 182 weld metal would propagate by Primary Water Stress Corrosion Cracking (PWSCC) through the weld to the interface with the carbon steel shell. It is fully expected that such a crack would then blunt and arrest at the weld-to-shell interface.

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 shell material are low, it is assumed that a small flaw could initiate in the carbon steel material and grow by fatigue. It is postulated that the small flaw in the shell would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the carbon steel shell by fatigue crack growth under cyclic loading conditions. Residual stresses have been determined and are included in the analysis (CR3 Document M03-0029, Revision 0).

Flaw evaluations are performed for a postulated radial corner crack. Hoop stresses are used since they are perpendicular to the plane of the crack. The life of the repair is determined based on fatigue crack growth and crack growth per year of operation. It has been calculated as 40 years of additional service. The final flaw size meets the fracture toughness requirements of the ASME Code using an upper shelf value of 200 ksi/in [sic] for ferritic materials. The results of this analysis indicate that it is acceptable to leave the postulated cracks in the attachment weld (J-groove) for the remaining life of the component.

An additional evaluation has been performed to determine the potential for debris damage resulting from a cracked J-groove partial penetration weld (CR3 Document M03-0037, Revision 0). As noted above, radial cracks are 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 identified forces that would drive a transverse crack. Only thermal and welding residual stresses could cause a transverse crack to grow. However, the presence of radial cracks limits the growth potential of the transverse cracks. 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. Even though highly unlikely, the analysis assumes worst case configurations of debris are generated by a cracked weld. The analysis concludes that there is an insignificant probability of damage to any RCS or Pressurizer component resulting from debris generated because of a cracked weld.

The cited evaluations provide an acceptable level of safety and quality in insuring that the Pressurizer shell remains capable of performing its design function with flaws existing in the original J-groove weld. See Attachment D for a summary of the supporting analyses. [*Attachment D is not included in this SE but was included in the licensee's submittal.*]

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 Primary Water Stress Corrosion Cracking (PWSCC). As shown by industry experience, the carbon steel shell of the Pressurizer impedes crack growth by PWSCC. CR3 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 demonstrated that the assumed worst case crack size will not grow to an unacceptable depth into the Pressurizer shell carbon steel base material over the life of the repair. Thus, the Pressurizer shell can be accepted per the requirements of IWA-4310.

3.2.5 Implementation Schedule:

This relief request is being implemented during the Third Inservice Inspection Interval and it is only applicable to the repairs to the pressurizer level instrument and sampling nozzle penetrations.

3.2.6 Staff Evaluation

The licensee submitted request for relief 03-0002-RR, Revision 0, to be implemented during the ongoing Refueling Outage 13 at CR3. In relief request 03-0002-RR, the licensee sought relief from the requirements of paragraph IWA-4310 of the ASME Code, Section XI, to determine the size of the flaws left in the J-groove weld of the nozzle and instead proposed to use the worst-case assumptions to conservatively estimate the size and orientation of flaws.

Paragraph IWA-4310 of the ASME Code, Section XI requires in part that defects be removed or reduced in size in accordance with the Code. The Code also allows that 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 ASME Code, Section XI. Subsection IWA-3300 of Section XI requires characterization of flaws detected by inservice examination.

The licensee requested relief from ASME Section XI, IWA-3300 because it assumed that flaws in the original pressurizer instrument or sampling nozzle to pressurizer shell J-groove weld will not be removed. Instead of fully characterizing the existing cracks, the licensee proposed to utilize worst-case assumptions to conservatively estimate the crack extent and orientation. To accomplish this goal, the licensee performed a fracture mechanics evaluation to determine if a degraded J-groove weld material could remain in the vessel with no examination to size any flaws that might remain following the repair. The evaluation assumed that a radial crack in the Alloy 182 weld metal would propagate by PWSCC through the weld to the interface with the carbon steel shell. Such a crack would then blunt and arrest at the weld-to-shell interface. 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 shell material are low, the evaluation assumed that a small flaw could initiate in the carbon steel material and grow by fatigue. It also postulated that the small flaw in the shell would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the carbon steel shell by fatigue crack growth under cyclic loading conditions. The life of the repair was determined based on fatigue crack growth and crack growth per year of operation. The life of the repair was calculated to provide 40 years of additional service. The final flaw size was determined to meet the fracture toughness requirements of the ASME Code using an upper shelf fracture toughness value of 200 ksi$\sqrt{in}$ for ferritic materials. The results of the licensee's analysis are documented in CR3 Document M03-0032, Revision 0. The analysis indicated that it is acceptable to leave the postulated cracks in the attachment weld (J-groove) for the remaining life of the component.

The NRC staff finds the licensee flaw evaluation approach acceptable because the licensee has utilized the worst-case assumptions to estimate the crack extent and orientation. Further, the NRC staff has previously approved this flaw evaluation approach for use at other nuclear power plant plants that have successfully repaired nozzles using the half-nozzle repair method.

The potential of corrosion mechanisms affecting the pressurizer nozzles were evaluated by the licensee. This evaluation was performed because the repair configuration leaves portions of the carbon steel material inside the pressurizer penetrations exposed to the primary reactor coolant. The exposure of the carbon steel material is caused by the existence of a small gap at the junction between the original (Alloy 600) and new (Alloy 690) nozzles. The analysis evaluated the long-term impact of the newly exposed carbon steel material to the reactor coolant. The results of the licensee's analysis are documented in CR3 Document M03-0030, Revision 0. The analysis concluded that the corrosion rate and release of iron into the reactor coolant system are negligible. The NRC staff concurs with the licensee's evaluation results that the long-term impact on exposed carbon steel material to reactor coolant is negligible because operating history of domestic power plants includes many cases where localized exposure of carbon steel to reactor coolant has been confirmed to be very low, on the order of 0.001 to 0.002 inch per year.

According to the licensee, the removal of 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 in request for relief 03-0001-RR, 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 carbon steel shell of the pressurizer impedes crack growth by PWSCC. Therefore, the alternative described in the licensee's submittal 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 demonstrated that the assumed worst-case crack size will not grow to an unacceptable depth into the pressurizer shell carbon steel base material over the life of the repair.

The NRC staff finds the licensee's reasoning in support of its request for relief acceptable. This is based on the fact that the licensee has demonstrated that the assumed worst-case crack size will not grow to an unacceptable depth into the pressurizer shell carbon steel base material over the life of the repair. Further, the long-term impact on exposed carbon steel material to reactor coolant is negligible because operating history of domestic power plants includes many cases where localized exposure of carbon steel to reactor coolant has been confirmed to be very low. As a result, the NRC staff concludes that the licensee has proposed an acceptable alternative to the requirements of IWA-3300 of ASME Code, Section XI.

4.0 CONCLUSION

Based on the information provided in the licensee's submittal, the NRC staff has determined that the licensee has provided an acceptable alternative to the requirements of ASME Code, Section XI, IWA-3300, IWA-4120(a), and IWA-4500, and Code Case N-638. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the licensee's proposed alternatives are authorized for the repair of pressurizer nozzles during the ongoing Refueling Outage 13 at CR3. All other requirements of the ASME Code, Sections 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.

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