Florida Power & Light Company, 6501 South Ocean Drive, Jensen Beach, FL 34957

FPL

September 26, 2002

L-2002-178
10 CFR 50.4
10 CFR 50.55a

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

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
In-Service-Inspection Plan
Unit 1 Third Ten-Year Interval
Unit 2 Second Ten-Year Interval
Contingency Reactor Vessel Head Penetration
Weld Repair and Flaw Evaluation Relief Requests

Florida Power and Light Company (FPL) requests approval of Relief Requests 20 and 30 pursuant to 10 CFR 50.55a (a)(3)(i) and Relief Requests 21 and 31 pursuant to 10 CFR 50.55a(g)(5)(iii). For Relief Requests 20 and 30, FPL has determined that pursuant to 10 CFR 50.55a (a)(3)(i) the proposed alternatives would provide an acceptable level of quality and safety. For Relief Requests 21 and 31, FPL has determined that pursuant to 10 CFR 50.55a(g)(5)(iii) it would be impractical to characterize the flaws by non-destructive examination (NDE) and it would be impractical to show the flaws do not extend into the ferritic base material.

Unit 1 Relief Requests 20 and 21 are needed to support potential corrective actions resulting from the NRC Bulletin (NRCB) 2001-01, NRCB 2002-01, and NRCB 2002-02 inspections. The NRCB inspections will be performed during the St. Lucie Unit 1 fall 2002 refueling outage (SL1-18). Approval of the Unit 2 Relief Requests 30 and 31 is requested to support the spring 2003 Unit 2 outage (SL2-14) scheduled to begin in late April 2003.

This submittal is a complete replacement of FPL letter L-2001-262 dated November 21, 2001 and incorporates NRC additional guidance provided during the review of similar relief requests for FPL's Turkey Point Plant. Please contact George Madden at 772-467-7155 if there are any questions about this submittal.

Very truly yours,

Donald E. Jernigan
Vice President
St. Lucie Plant

DEJ/GRM

Attachments (2)

A047

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

REPAIR OF REACTOR VESSEL CLOSURE HEAD PENETRATION WELDS

I. COMPONENT IDENTIFICATION:

St. Lucie (PSL) Unit 1 and Unit 2
Reactor Vessel Closure Head CEDM Nozzle Penetrations, Class 1
FPL Drawing No. 8770-1423 Rev. 8 (PSL-1)
FPL Drawing No. 2998-3130 Rev. 4 (PSL-2)

II CODE REQUIREMENT:

ASME Section XI, paragraph IWA-4120, stipulates the following: "Repairs 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."

III. RELIEF REQUESTED:

Pursuant to 10 CFR 50.55a (a)(3)(i), relief is requested to utilize alternative welding requirements than contained in the Construction Code of Record. The alternative requirements provide an acceptable level of quality and safety.

The Construction Code of record for the St. Lucie Unit 1 reactor pressure vessel closure (RPV) head is the 1965 Edition of the ASME Boiler and Pressure Vessel Code, Section III through Winter of 1967 Addenda. For St. Lucie Unit 2 the Construction Code of record is the 1971 Edition of the ASME Boiler and Pressure Vessel Code, Section III through Summer 1972 Addenda.

For the contemplated repairs to the RPV head CEDM nozzle penetrations, both Construction Codes require repairs to be post weld heat-treated (PWHT) in accordance with their requirements. The PWHT requirements set forth therein would be extremely impractical to attain on a RPV head in containment without distortion of the head. In addition, the existing penetration to head welds were not qualified with PWHT and cannot be so qualified at this time.

The proposed repairs will be conducted in accordance with the ASME Boiler & Pressure Vessel Code, Section III, Subsection NB, 1989 Edition, no Addenda and the following alternative requirements.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

FPL is proposing to sever the weld joining a leaking CEDM nozzle penetration to the head and make a new weld, in accordance with the requirements of ASME Section III, at a slightly removed location, to rejoin the CEDM nozzle penetration to the head. The welding will be performed with a remotely operated weld tool, utilizing the machine Gas Tungsten-Arc Welding (GTAW) process and the ambient temperature temper bead method with 50 degree F minimum preheat temperature and no post weld heat treatment.

Specifically relief is requested from the following Code requirements:

- NB-4622.1 and NB-4622.5 requires post weld heat treatment. However, FPL proposes to use a temper bead welding technique using ambient preheat and no post weld heat treatment.

- NB-5245 requires a progressive surface examination (PT or MT) at the lesser of 1/2 the maximum weld thickness or 1/2-inch as well as a surface examination on the finished weld. FPL proposes a liquid penetrant and ultrasonic examination, only on the final weld surface, no sooner than 48 hours after the weld has cooled to ambient temperature.

- NB-6111 requires a hydrostatic test. FPL proposes a system leakage test.

IV. WELD REPAIR METHOD:

FPL plans to replace the CEDM nozzle penetration weld by welding the CEDM nozzle (P-No. 43 base metal) to the RPV head (P-No.3 base metal) with filler metal (F-No. 43), at a slightly higher location, in accordance with the following:

- General Requirements:

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

If a defect penetrates into the ferritic base metal, repair of the base metal, using a nonferritic weld filler metal, may be performed provided the depth of repair in the base metal does not exceed 3/8-inch and the excavation is within the intended new weld boundary.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

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

Welding filler metal will meet the requirements of the design specification, construction code and code cases specified in the repair program. Welding filler metals will be controlled so they are identified as acceptable until consumed.

Peening will not be used; however, the weldment final surface will be abrasive water jet conditioned to impart a compressive stress layer to produce resistance to PWSCC.

- Welding Qualifications:

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

- Procedure Qualification

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

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

The maximum interpass temperature for the first three layers of the test assembly will be 150 degrees F.

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

Ferritic base metal for the procedure qualification test will meet the impact test requirements at or below the lowest service temperature.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

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

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

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

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

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

If the average Charpy V-notch lateral expansion for the heat affected zone is less than that for the unaffected base metal, and the qualification test meets the other criteria of acceptance, the Charpy V-notch test results may be recorded on the Welding Procedure Qualification Record. Data shall then be obtained as specified below to provide an additive temperature for any base metal for which the welding procedure is being qualified, and shall be included. Alternatively, the welding procedure qualification may be rewelded and retested.

The data to provide an additive temperature shall be developed by performing additional Charpy V-notch tests on either the welding procedure qualification heat affected zone or the unaffected base metal, or both, at temperatures which provide lateral expansion values equal or greater than 35 mils. The average lateral expansion data for the heat affected zone and the unaffected base metal shall be plotted on a lateral expansion-temperature chart. The temperatures at which these two sets of data exhibit a common lateral expansion value equal to or greater than 35 mils shall be determined. The determined temperature for the

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

unaffected base metal shall be subtracted from the similarly determined temperature for the heat-affected zone. This difference shall be used as the adjustment temperature. The adjustment temperature shall be added to the highest reference temperature (RT_{NDT}) for all of the base metals to be welded by this procedure in production. If the temperature difference is zero or is a negative number, no adjustment is required for the base metal to be welded in production.

- Performance Qualification

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

- Welding Procedure Requirements

The weld metal will be deposited by machine GTAW process.

The dissimilar metal weld shall be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints.

The area to be welded will be buttered with a deposit of at least three layers to achieve at least 1/8-inch overlay thickness as shown in Figure 2, Steps 1 through 3. The heat input for each layer will be controlled to within ±10% of that used in the procedure qualification test. Particular care will be taken in placement of the weld beads on the ferritic metal to ensure that the HAZ (ferritic base metal) is tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

The maximum interpass temperature for field applications will be 350 degrees F regardless of the interpass temperature during qualification. The new weld is inaccessible for mounting thermocouples near the weld; therefore, recording instruments will not be used to monitor interpass temperature.

- Examination

Prior to welding, a liquid penetrant surface examination will be performed on the area to be welded; coverage is shown in Figure 5.

The final weld surface and a surrounding band will be examined using liquid penetrant (PT) and ultrasonic (UT) methods when the completed weld has been at ambient temperature for at least 48 hours.

PT coverage is shown in Figure 6.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

UT will be performed scanning from the ID surface of the weld and adjacent portion of the CEDM nozzle bore. The UT scan will extend downward on the replacement lower CEDM nozzle stub to obtain additional weld volume coverage. The UT is qualified to detect flaws in the weld and base metal interface in the weld region, to the maximum practical extent. The examination extent is consistent with the Construction Code requirements. UT coverage is shown in Figures 8 through 12.

NDE personnel will be qualified in accordance with NB-5500.

Liquid penetrant examination acceptance criteria will be in accordance with NB-5350. Ultrasonic examination acceptance criteria will be in accordance with NB-5330.

- Documentation

The repair will be documented on Form NIS-2A.

V. JUSTIFICATION FOR USE OF ALTERNATIVE:

This proposed alternative temper bead welding process provides an equivalent acceptable level of quality and safety to the welding process requiring post weld heat treatment described in ASME, Section III Subsection NB 1989 Edition, no Addenda. The repair process, technical justification, and occupational exposure savings are described below:

Repair Process:

CEDM nozzles that are determined to have through-wall leakage will be repaired/modified. The CEDM nozzle repair configuration is illustrated in Figures 3 and 4.

Remotely controlled machine processes are planned for all examination, metal removal and welding. Metal removal and liquid penetrant examination may be done manually if machine processes are not practical.

The lower portion of the thermal sleeves on PSL-1 and the guide funnels on Unit 2 will be removed by remotely operated methods to the extent practical.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

Using a remote tool from below the RPV head, each of the leaking CEDM nozzles will first receive a roll expansion into the RPV head base metal to insure that the nozzle will not move during the welding operations.

A semi-automated machining tool operating underneath the RPV head will remove the entire lower portion of the CEDM nozzle to a location above the existing J-groove partial penetration weld. The machine tool will also form the CEDM nozzle weld preparation. The operation will sever the existing J-groove partial penetration weld from the subject CEDM nozzles. The extent of the weld preparation will insure that the new weld will not overlap the old weld.

The machined surface will be cleaned prior to liquid penetrant examination (PT).

The repair will establish a new pressure boundary weld between the shortened CEDM nozzle and the inside bore of the penetration in the RPV head. The replacement lower nozzle will be welded at this time. Welding will be performed with a remotely operated machine GTAW weld head using the temper bead process. Minimum preheat temperature will be 50 degrees F and the welding filler metal will be ERNiCrFe-7 (Alloy 52).

Preheat temperature will be monitored using contact pyrometers and/or thermocouples on accessible portions of the RPV head external surface(s).

The RPV head temperature will be essentially the same as the reactor building ambient temperature which exceeds 50 degrees F; therefore RPV head preheat temperature monitoring in the weld region is unnecessary.

The final weld face will be machined and/or ground.

The final weld will be liquid penetrant and ultrasonically examined prior to subsequent abrasive water-jet conditioning.

The final inside diameter surface of the CEDM nozzle near the new weld and the new weld will then be conditioned by abrasive water-jet machining to produce a final surface that is in compression to produce optimum resistance to primary water stress corrosion cracking.

A replacement funnel will be installed on the replacement lower nozzle.

A system leakage test will be performed.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

Technical Justification:

- Relief from NB-4622.1 and NB-4622.5

Quality temper bead welds, without preheat and postheat, can be made based on welding procedure qualification test data derived from machine GTAW ambient temperature temper bead welding process. The proposed alternative welding technique has been demonstrated as an acceptable method for performing welds without preheat and post heat. The ambient temperature temper bead technique has been approved by the NRC as having an acceptable level of quality and safety and was successfully used at several sites (Duane Arnold, Nine Mile Point, Fitzpatrick, Crystal River, Oconee 1 and 3, Surry 1, Millstone 2 and TMI-1).

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 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 EPRI and other organizations. (Reference EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper bead Applications," dated November 1998.) The research demonstrates that carefully controlled heat input and bead placement allow subsequent welding passes to relieve stress and temper the heat affected zones (HAZ) of the base metal and preceding weld passes. Data presented in Tables 4-1 and 4-2 of the report show the results of procedure qualifications performed with 300 degree F preheats and 500 degree F post-heats, as well as with no preheat and post-heat. From that data, it is clear that equivalent toughness is achieved in base metal and heat affected zones 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 Procedure Qualifications Records (PQRs) and Welding Procedure Specifications (WPSs) presently exist and have been used to perform numerous successful repairs. These repairs have included all of the Construction Book Sections of the ASME Code, as well as the National Board Inspection Code (NBIC). The use of the automatic or machine GTAW process utilized for temper bead welding allows more precise control of heat input, bead placement, and bead size and contour than the manual shielded metal arc welding (SMAW) process required by 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.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

The NB-4622.11 temper bead procedure requires a 350 degrees F minimum preheat temperature and a postweld soak temperature of 450-550 degrees F for 4 hours for P-No. 3 metals. Typically, these kinds of restrictions are used to mitigate the effects of the solution of atomic hydrogen in ferritic metals prone to hydrogen embrittlement cracking. The susceptibility of ferritic steels is directly related to their ability to transform to martensite without appropriate heat treatment. The P-No. 3 base metal of the reactor vessel head is able to produce martensite from the heating and cooling cycles associated with welding. However, the proposed alternative mitigates this propensity without the use of elevated preheat and postweld hydrogen bake out.

The NB-4622.11 temper bead procedure requires the use of the SMAW welding process with covered electrodes. The electrodes required by NB-4622.11, may be a source of hydrogen unless very stringent electrode storage and handling procedures are followed. The only shielding of the molten weld puddle and surrounding metal from moisture in the atmosphere (a source of hydrogen) is the evolution of gases from the flux and the slag that forms from the flux and covers the molten weld metal. As a consequence of the possibility for contamination of the weld with hydrogen, NB-4622 temper bead procedures require preheat and postweld hydrogen bake-out. However, the proposed alternative temper bead procedure utilizes a welding process that is inherently free of hydrogen. The GTAW process relies on bare welding electrodes with no flux to trap moisture. An inert gas blanket positively shields the weld and surrounding metal 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. 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. Additionally, the F-No. 43 (ERNiCrFe-7) filler metal to be used for the repairs is not subject to hydrogen embrittlement cracking.

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

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

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

A welding mockup on the full size Midland RPV head, which is similar to the PSL RPV heads, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the head during welding. Thermocouples were placed on the outside surface of the RPV head within a 5-inch band surrounding the CRDM nozzle. Three other thermocouples were placed on the RPV head inside surface. One of the three thermocouples was placed 1-1/2 inches from the CRDM nozzle penetration, on the lower hillside. The other inside surface thermocouples were placed at the edge of the 5-inch band surrounding the CRDM nozzle, one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 15 degrees F throughout the 18-hour welding cycle. Based on past experience, it is believed that the temperature fluctuation was due more to the resistance heating temperature variations than the low heat input from the welding process. For the Midland RPV head mockup application, 300 degrees F minimum preheat temperature was used. Therefore, for ambient temperature conditions used for the weld proposed herein, the 350 degrees F maximum interpass temperature will certainly not be exceeded.

The automated repair method described above leaves a slight gap, between the replacement lower nozzle and the bore in the RPV head, which would expose a small amount of ferritic low alloy steel to the primary coolant. The effect of corrosion on the exposed area, both reduction in RPV head thickness and primary coolant Iron (Fe) release rates, has been evaluated by Framatome-ANP (FRA-ANP). The results of this evaluation concluded that the total corrosion would be insignificant when compared to the thickness of the RPV closure head. It was also concluded that the total estimated Fe release (from a total of all replaced CEDM nozzles) would be significantly less than the total Fe release from all other sources.

- Relief from NB-5245

The areas to be examined are shown in Figure 7. The UT transducers and delivery tooling are capable of scanning from cylindrical surfaces with inside

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

diameters near 2.75 inches. The total weld surface will be scanned. The transducers to be used are shown in Table 1. The UT coverage volumes are shown in Figures 8 through 12 for the various scans. Additionally, the final modification configuration and surrounding ferritic steel area affected by the welding is inaccessible or extremely difficult to obtain the necessary access and scans.

UT will be performed in lieu of RT due to the repair weld configuration. Meaningful RT cannot be performed as can be seen in the applicable figures. The weld configuration and geometry of the penetration in the RPV head provide an obstruction for the x-ray path and interpretation would be very difficult. UT will be substituted for the RT and qualified to evaluate defects in the repair weld and at the base metal interface. This examination method is considered adequate and superior to RT for this geometry. The new structural weld is sized like a coaxial cylinder partial penetration weld. Section III construction rules require progressive PT of partial penetration welds. The Section III original requirements for progressive PT were in lieu of volumetric examination. Volumetric examination is not practical for a conventional partial penetration weld configuration. However, in this case, the weld is suitable for UT and a final surface PT will also be performed.

The effectiveness of the UT techniques to characterize the weld defects has been qualified by demonstration on a mockup of the temper bead weld involving the same metals used for repair. Notches were machined into the mockup at depths of 0.10", 0.15", and 0.25" in order to quantify the ability to characterize the depth of penetration into the nozzle. The depth characterization is done using tip diffraction UT techniques that have the ability to measure the depth of a reflector relative to the nozzle bore. Each of the notches in the mockup could be measured using the 45-degree transducer. During the examination, longitudinal wave angle beams of 45 degrees and 70 degrees are used. These beams are directed along the nozzle axis looking up and down. The downward looking beams are effective at detecting defects near the root of the weld because of the impedance change at the triple point. The 45-degree transducer is effective at depth characterization by measuring the time interval to the tip of the reflector relative to the transducer contact surface. The 70-degree longitudinal wave provides additional qualitative data to support information obtained with the 45-degree transducer. Together, these transducers provide good characterization of possible defects. These techniques are routinely used for examination of austenitic welds in the nuclear industry for flaw detection and sizing.

In addition to the 45 and 70-degree beam angles described above, the weld is also examined in the circumferential direction using 45-degree longitudinal waves

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

in both the clockwise and counterclockwise directions to look for transverse fabrication flaws. A 0-degree transducer is also used to look radially outward to examine the weld and adjacent metal for laminar type flaws and evidence of under bead cracking.

The final weld surface and a band around the weld area will be examined using PT as shown in Figure 6.

The purpose for the examination of the band is to assure all flaws associated with the weld area have been removed or addressed. The final modification configuration and surrounding ferritic steel area affected by the welding is inaccessible or extremely difficult to obtain the necessary access. The final examination of the new weld and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy RPV head metal due to the welding process. The PT examination extent is consistent with the Construction Code requirements. Also, elimination of the band PT will result in reduction in dose to personnel.

- Relief from NB-6111

ASME III NB-6111 requires hydrostatic pressure testing of all pressure retaining components, appurtenances and completed systems. In lieu of hydrostatic testing of the repair, a system leakage test with a 4-hour hold time will be performed.

A Code hydrostatic test subjects the piping systems to a small increase in pressure over the nominal operating pressure and is not intended to present a significant challenge to pressure boundary integrity. It is used primarily as a means to enhance leakage detection during the examination of components under pressure, rather than as a measure to determine the structural integrity of components.

Industry experience has demonstrated that leaks are not being discovered as a result of hydrostatic test pressures propagating a pre-existing flaw through wall. Most leaks are being found when the system is at normal operating pressure. Hydrostatic tests are time consuming, require extensive operator support, and usually mean radiation exposure to personnel. Often, additional equipment must be brought in to test a localized repair that may involve additional exposure and expense. In many cases, a system hydrostatic test must be conducted over large parts of the system. In this case, the entire reactor coolant system would be subjected to the hydrostatic test.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

Hydrostatic tests place a burden on the systems, increase radiation exposure and costs, require significant setup time, and add marginal value to the repair quality. These tests result in hardships without a compensating increase in the level of quality and safety. Performing the tests in accordance with the proposed alternative will provide reasonable assurance that flaws will be discovered.

It can be concluded that quality temper bead welds can be performed with 50 degrees F minimum preheat and no post heat treatment based on FRA-ANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding. The qualification of the ambient temperature temper bead welding process demonstrates that the proposed alternative provides an acceptable level of quality and safety.

Occupational Exposure:

Recent experience gained from the performance of manual welds at other plants' CRDM/CEDM nozzles indicated that more remote automated repair methods were needed to reduce radiation dose to personnel and still provide acceptable levels of quality and safety. Since FPL recognizes the importance of ALARA principles, this remote welding method has been developed for the possibility of leaking nozzles at St. Lucie Units 1 and 2.

This approach for repair of leaking CEDM nozzles will significantly reduce radiation dose to personnel while still maintaining acceptable levels of quality and safety. The total radiation dose (assuming one nozzle for estimation purposes) for the proposed remote repair method is projected to be approximately 7.5 REM. In contrast, use of manual methods for St. Lucie Unit 1 or Unit 2 would result in a total radiation dose of approximately 32 REM.

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

VI. Implementation Schedule:

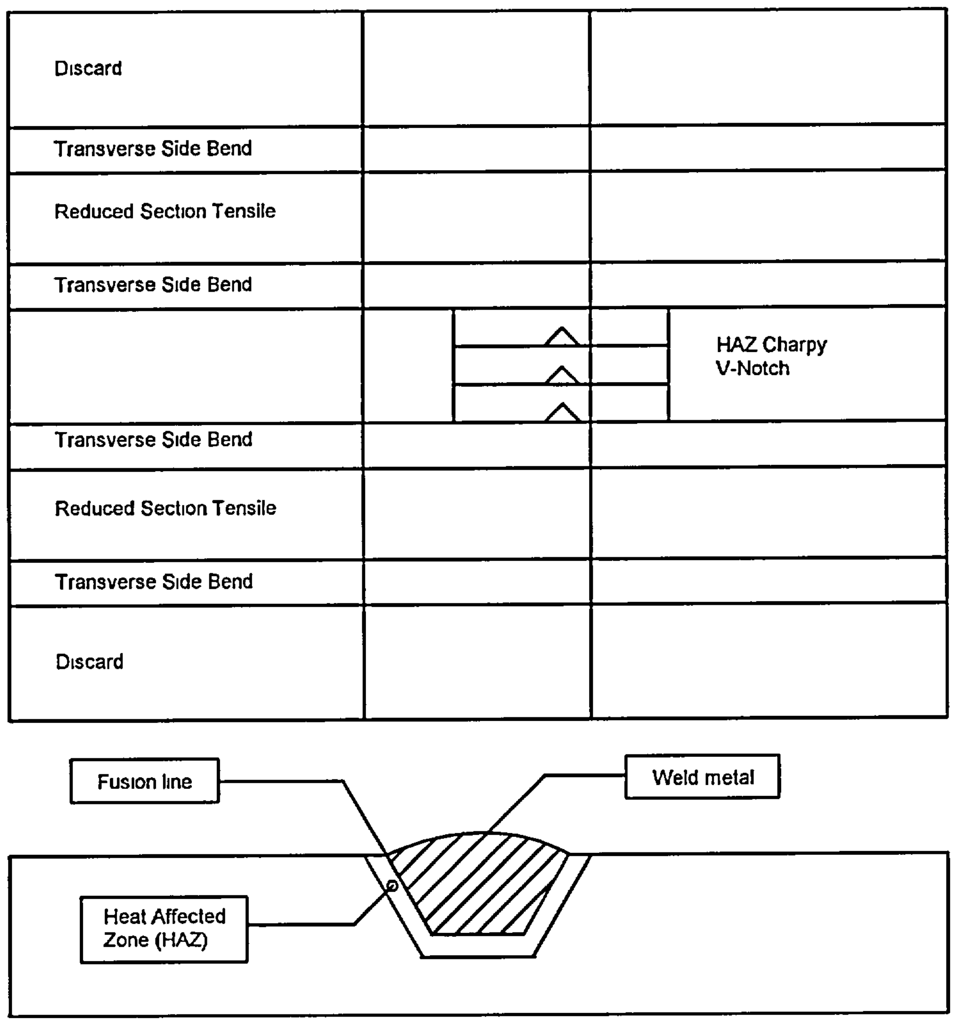
This relief is scheduled to be implemented, if required, during the fall 2002 refueling outage planned for Unit 1. This relief will also be implemented, if required, for any future examinations of the reactor vessel head penetrations for leakage on either Unit 1 or Unit 2.

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

Table 1:
PSL1 and PSL2 CEDM Repair Weld
UT Search Unit Transducer Characteristics

Angle/Mode	Freq.	Size	Focal Depth	Beam Direction
0° L-wave	2.25 MHz	.15" x .30"	0.45"	N/A
45° L-wave	2.25 MHz	.30" x .20"	0.45"	Axial
70° L-wave	2.25 MHz	.72" x .21"	0.69"	Axial
45° L-wave (effective)	2.25 MHz	.30" x .20"	0.45"	Circ.

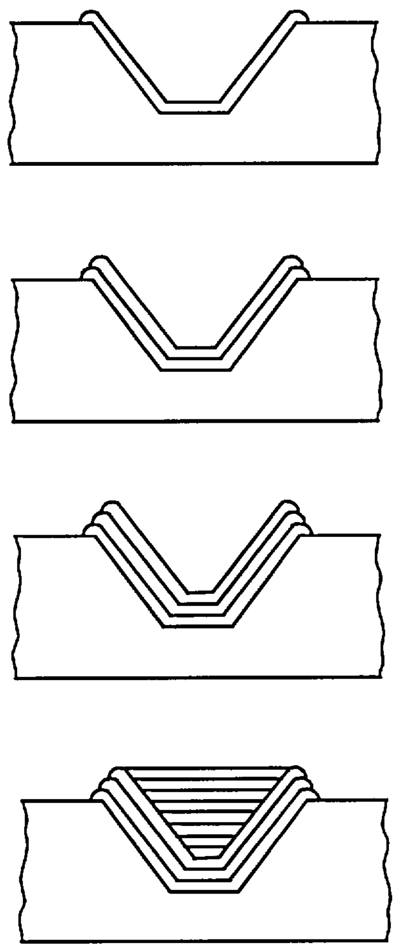
St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2



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

Figure 1
Qualification Test Plate

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2



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

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

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

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

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

Figure 2
Automatic or Machine GTAW Temper Bead Welding

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

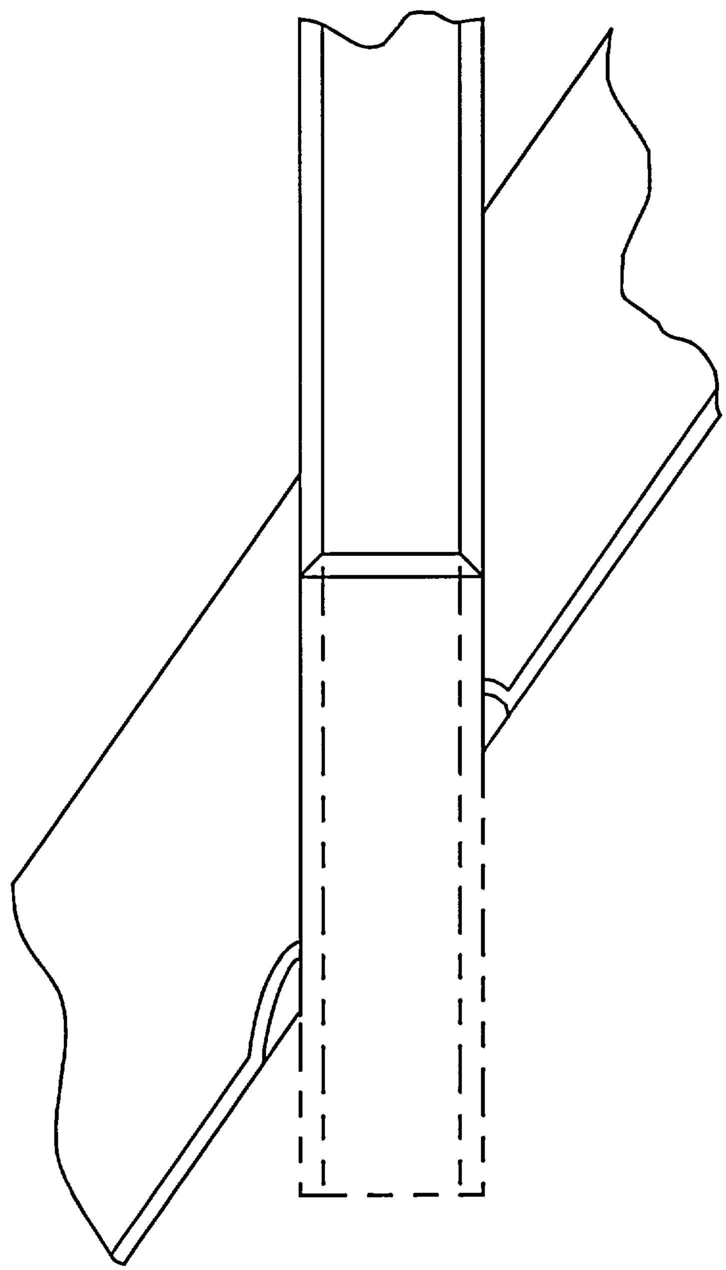


Figure 3
PSL1 and PSL2
CEDM Machining

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

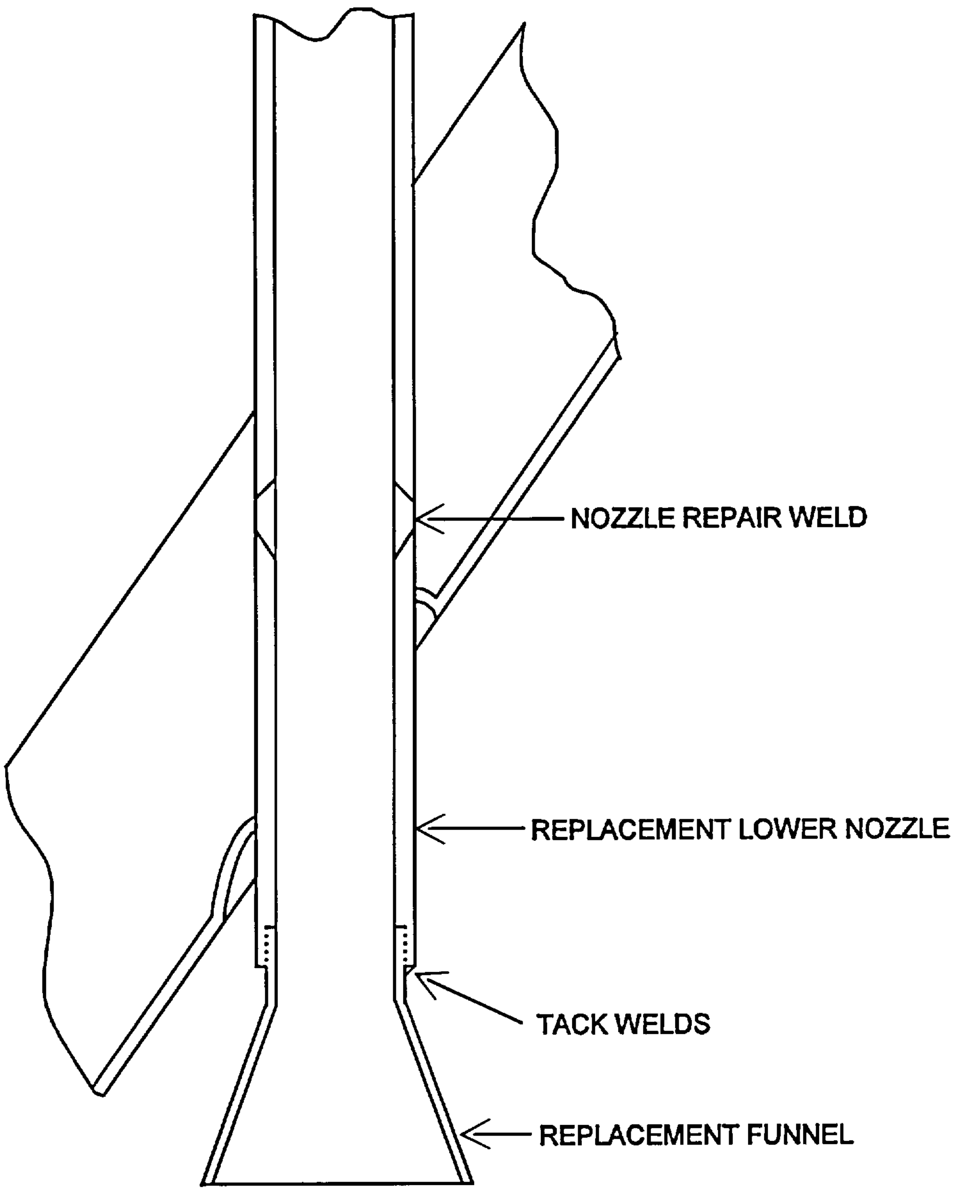


Figure 4
PSL1 and PSL2
New CEDM Pressure Boundary

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St. Lucie Unit 2 Relief Request No. 30 Revision 2

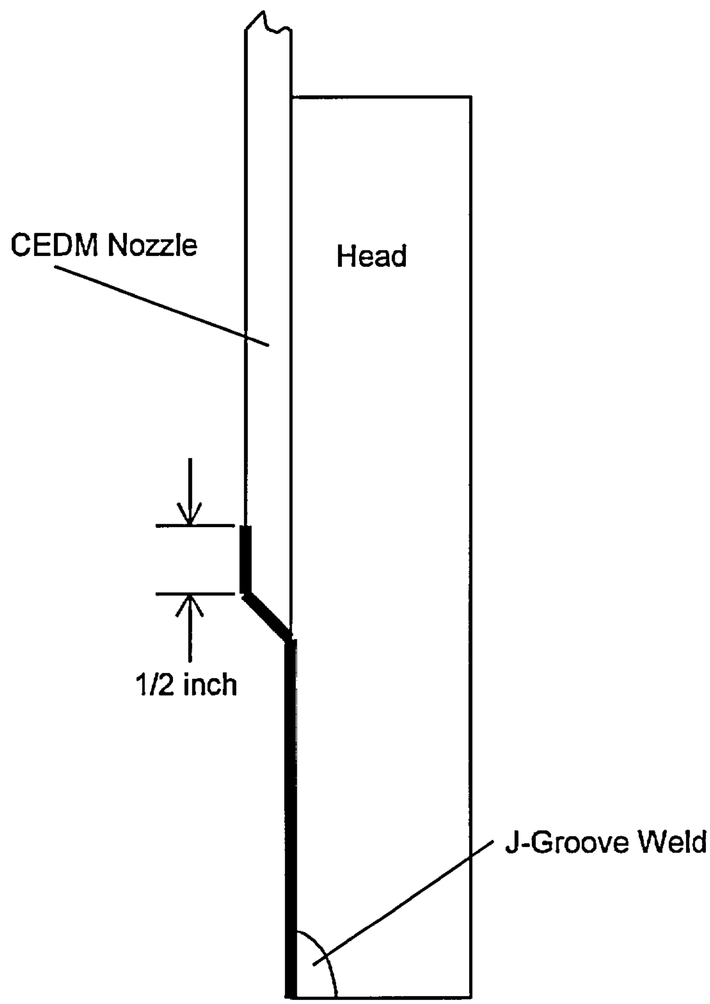

Figure 5
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
PT Coverage Prior to Welding

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

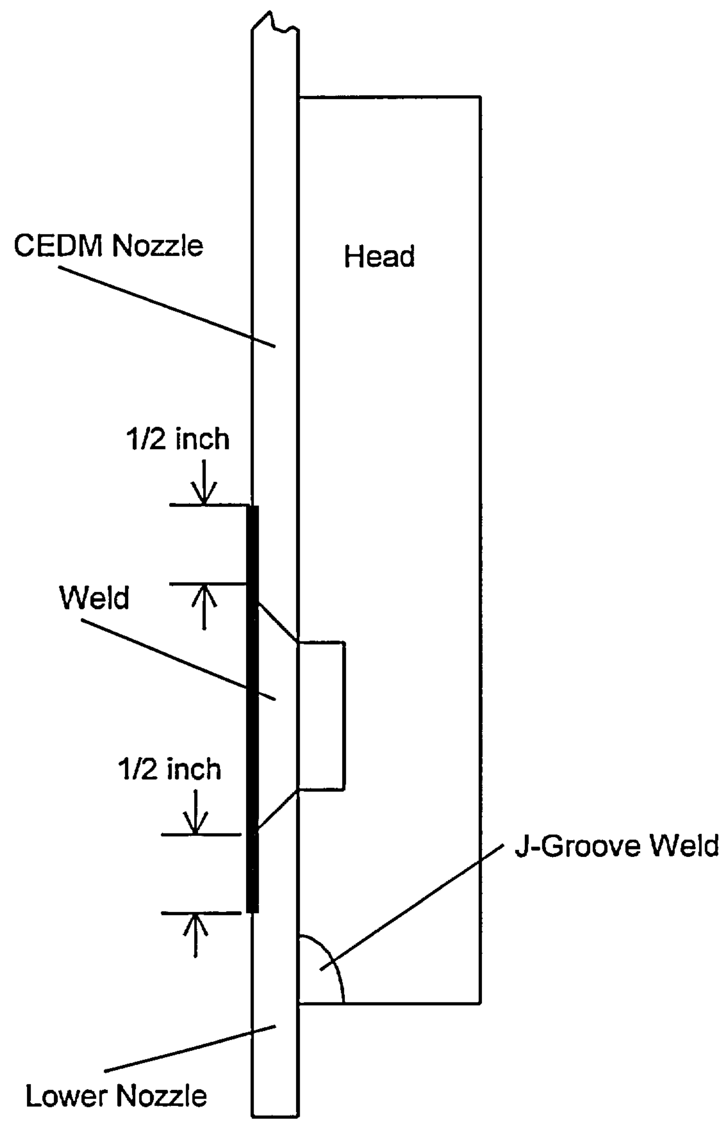

Figure 6
PLS1 and PSL2
CEDM Temper Bead Weld Repair,
PT Coverage After Welding

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St. Lucie Unit 2 Relief Request No. 30 Revision 2

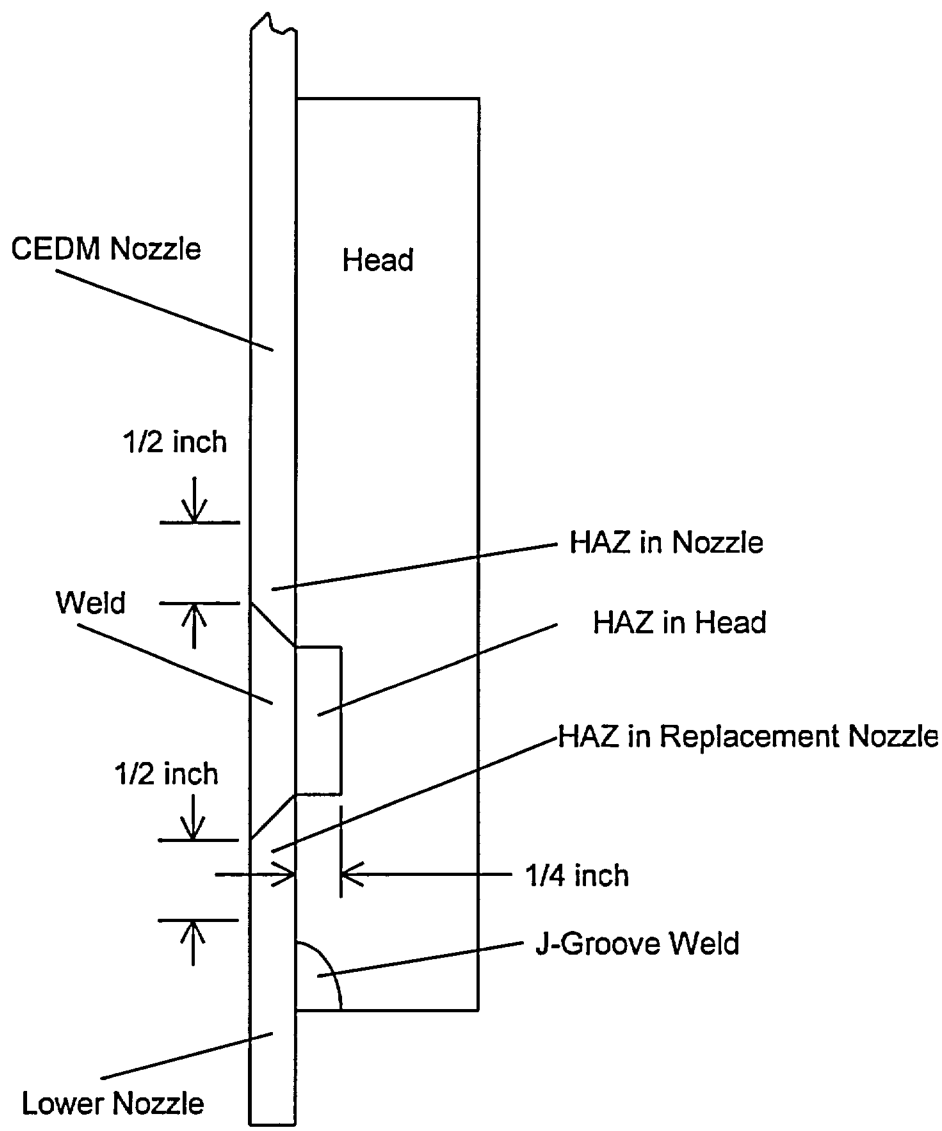

Figure 7
PSL1 and PSL2
CEDM Temper Bead Weld Repair
Areas to be Examined

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

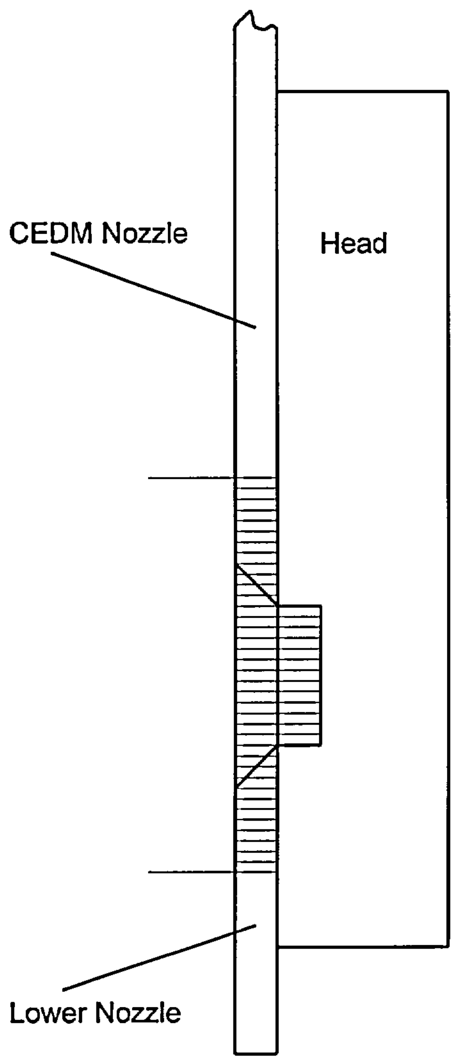

Figure 8
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
UT 0 degree and 45L Beam Coverage
Looking Clockwise and Counter-clockwise

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

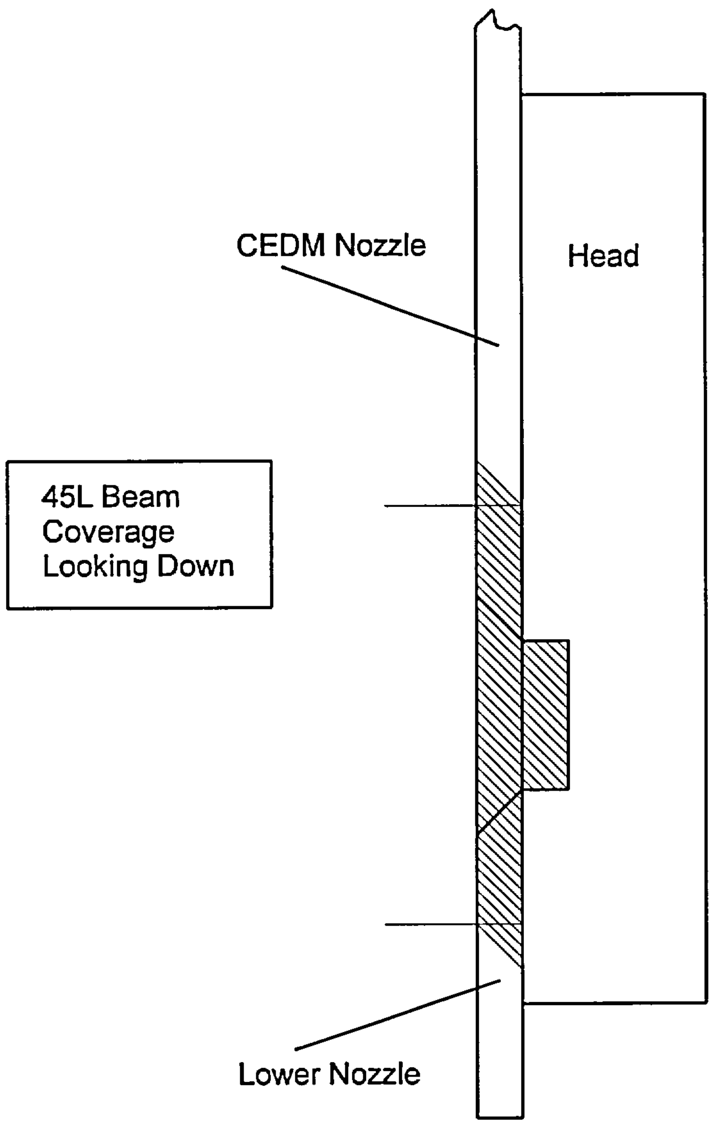

Figure 9
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
45L UT Beam Coverage Looking Down

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

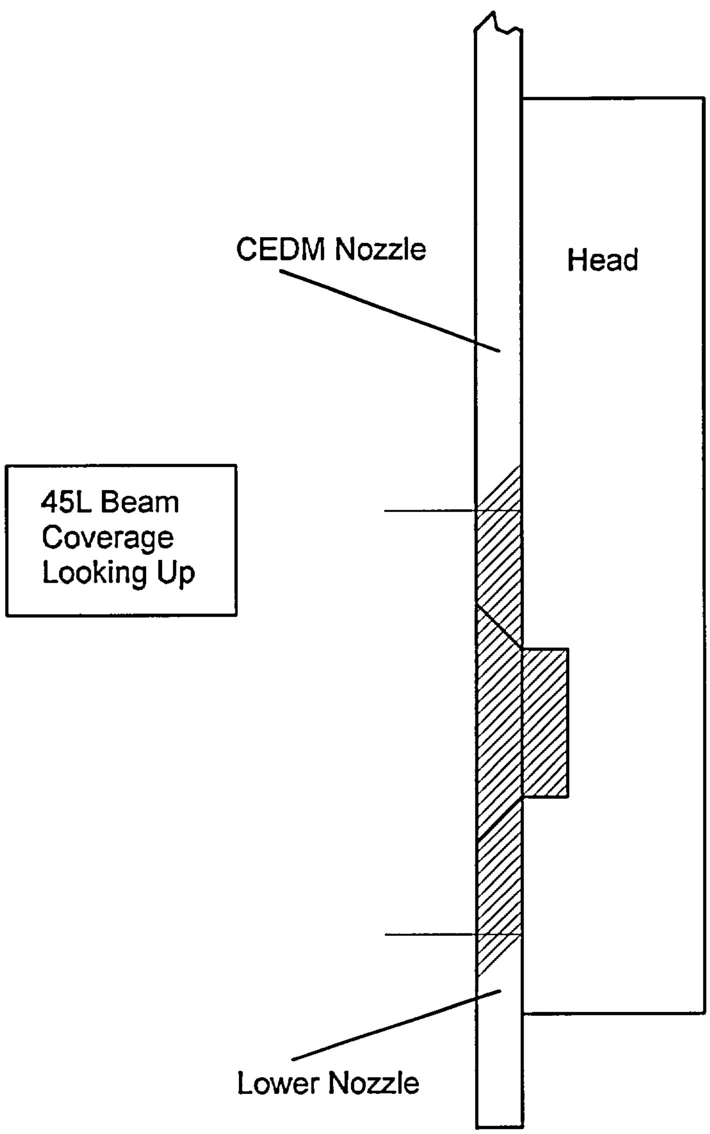

Figure 10
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
45L UT Beam Coverage Looking Up

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

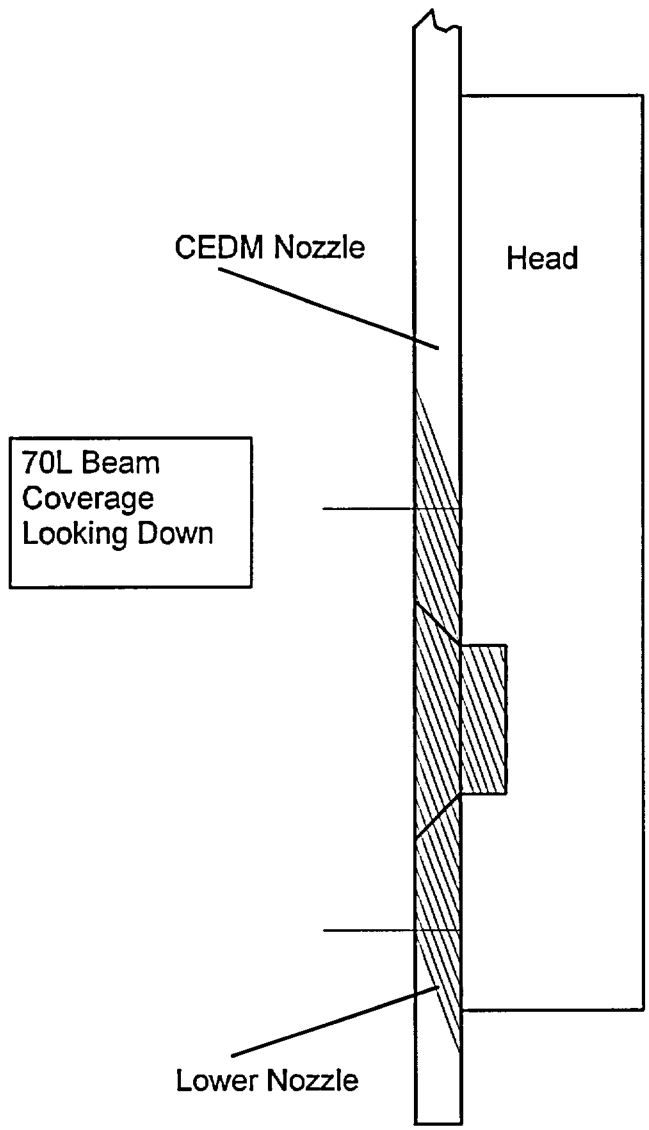

Figure 11
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Down

St. Lucie Unit 1 Relief Request No. 20 Revision 2
St. Lucie Unit 2 Relief Request No. 30 Revision 2

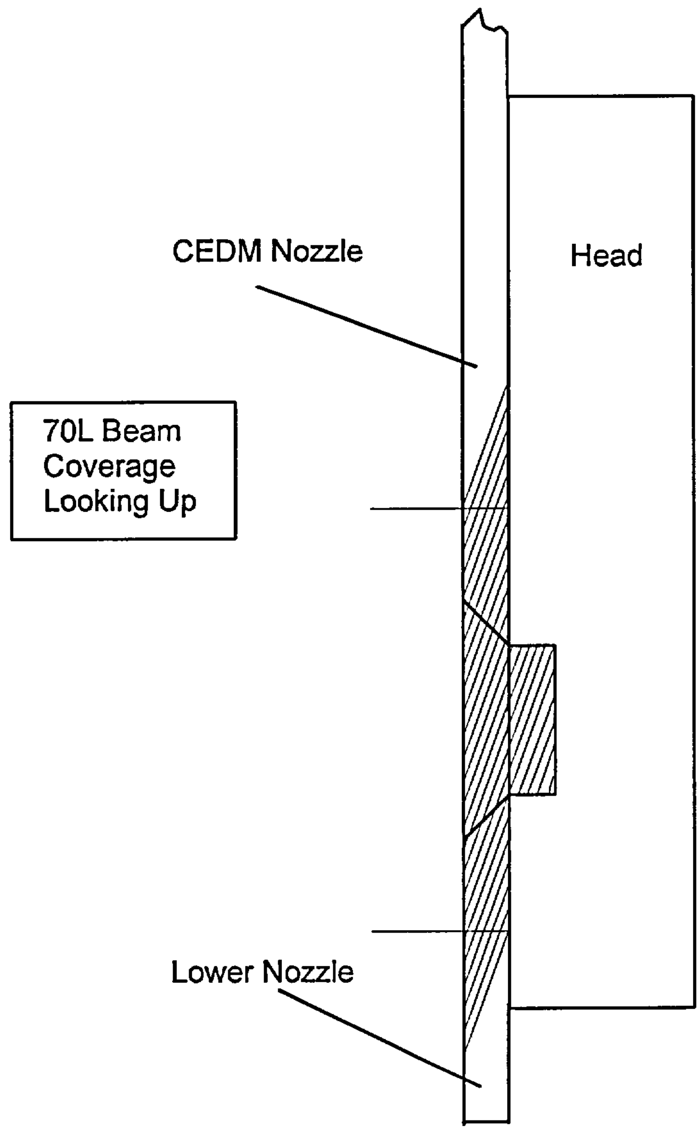

Figure 12
PSL1 and PSL2
CEDM Temper Bead Weld Repair,
70L UT Beam Coverage Looking Up

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

CHARACTERIZATION OF REMAINING FLAWS

I. COMPONENT IDENTIFICATION

St. Lucie (PSL) Unit 1 and Unit 2
Reactor Vessel Closure Head CEDM Nozzle Penetrations, Class 1
FPL Drawing No. 8770-1423 Rev. 8 (PSL-1)
FPL Drawing No. 2998-3130 Rev. 4 (PSL-2)

II. CODE REQUIREMENT:

ASME Sect. XI, 1989 Edition, no Addendum, IWA-3100 (a) Evaluation shall be made of flaws detected during an inservice examination as required by IWB-3000 for Class 1 pressure retaining components.

III. RELIEF REQUESTED:

Pursuant to 10 CFR 50.55a (g)(5)(iii), relief is requested from ASME XI which requires flaw characterization. It will be impractical to characterize the subject flaws by NDE and it will be impractical to show bounding flaws do not extend into the ferritic head base material.

Specifically, relief is requested from the following parts of the Code:

- IWA-3300(b) and IWB-3420; in lieu of flaw characterization, ASME Section XI calculations will be performed to show the flaws are acceptable.
- IWB-2420(b) and IWB-2420(c); reexamination for the next three inspection periods; since initial inspection is impractical, subsequent inspections will also be impractical and will not be performed.

IV. JUSTIFICATION FOR RELIEF:

The reactor pressure vessel closure (RPV) head will be examined for evidence of leakage at the junction of the head penetrations. Penetrations with evidence of leakage will be investigated and penetrations with verified leakage will be repaired as detailed herein. The repair method will not remove any indications found at the original weld joining the penetration to the head interior or the associated buttering. Due to the geometry of the weld area, it is impractical to characterize such indications.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

The original CEDM nozzle to RPV head weld configuration is extremely difficult to UT due to the compound curvature and fillet radius as can be seen in Figure 1. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore, it is impractical, and presently, the technology does not exist to characterize flaw geometry that may exist therein. 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 RPV head increases the UT difficulty. Furthermore, due to limited accessibility from the RPV head outer surface and the proximity of adjacent nozzle penetrations, it is impractical to scan from this surface on the RPV head base material to detect flaws in the vicinity of the original weld. As a clarification, this inability to characterize the flaw will continue in the foreseeable future and subsequent examinations will also be impractical. It has therefore been assumed, for analysis purposes, that a flaw(s) may exist in this weld that extends from the weld surface to the weld to RPV head base material interface. Based on extensive industry experience and Framatome ANP direct experience, there are no known cases where flaws initiating in an Alloy 82/182 weld have propagated into the ferritic base material.

The worst-case assumption on flaw size is based on maximum crack growth by primary water stress corrosion cracking (PWSCC). Although a crack propagating through the J-groove weld by PWSCC would eventually grow to the low alloy steel RPV head, continued growth by PWSCC into the low alloy steel is not expected to occur. Stress corrosion cracking (SCC) of carbon and low alloy steels is not a problem under BWR or PWR conditions. SCC of steels containing up to 5% chromium is most frequently observed in caustic and nitrate solutions and in media containing hydrogen sulfide. Based on this information, SCC is not expected to be a concern for low alloy steel exposed to primary water. Instead, an interdendritic crack propagating from the J-groove weld area is expected to blunt and cease propagation. This has been shown to be the case for interdendritic SCC of stainless steel cladding cracks in charging pumps and by recent events with PWSCC of Alloy 600 weld materials at ONS-1 and VC Summer.

The surface examinations performed associated with flaw removal during recent repairs at Oconee 1 and 3 on RPV head CRDM nozzle penetrations, Catawba 2 steam generator channel head drain connection penetration, ANO-1 hot leg level tap penetrations, and the VC Summer hot leg pipe to primary outlet nozzle repair all support the assumption that the flaws would blunt at the interface of the Ni-Cr-Fe weld to ferritic base material.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

It will be shown to be acceptable to leave the postulated cracks in the original Ni-Cr-Fe housing nozzle penetration J-prep buttering, or in the original Ni-Cr-Fe CEDM housing to RPV head attachment weld. The evaluations performed in support of this relief will provide an equivalent acceptable level of quality and safety without performing flaw characterization as required in ASME, Section XI 1989, IWA-3300 (b) and IWB-3420.

ASME Section XI stress calculations will be performed to show the flaws are acceptable for a number of years. The only driving mechanism is fatigue crack growth. The evaluation will assume a radial (with respect to the penetration centerline) crack exists with a length equal to the partial penetration weld preparation depth.

An analysis of the new pressure boundary welds will be performed using a 3-dimensional model of a CEDM nozzle located at the most severe hillside orientation. The software program ANSYS (a general purpose finite element program that is used industry-wide) will be used for this analysis. Per FRA-ANP internal procedures, the ANSYS computer code is independently verified as executing properly, by the solution of verification problems using ANSYS and then comparison of the results to independently determined values.

The analytical model will include the RPV head, CEDM nozzle, repair weld, and remnant portions of the original Ni-Cr-Fe welds. The model is analyzed for thermal transient conditions as contained in the St. Lucie Unit 1 and Unit 2 design specifications. The resulting maximum thermal gradients will be applied to the model along with the coincident internal pressure values. The ANSYS program will then calculate the stresses throughout the model (including the repair welds). The stresses will be post-processed by ANSYS routines to categorize stresses consistent with the criteria of the ASME Code.

The calculated stress values are compared to the ASME Code, Section III, NB-3000 criteria for:

- Design Conditions
- Normal, Operating, and Upset Conditions
- Emergency Conditions
- Faulted Conditions
- Testing Conditions

A very conservative Stress Concentration Factor (SCF) of 4.0 will be assumed for the new pressure boundary weld.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

A primary stress analysis for design conditions will be performed. A maximum Primary General Membrane Stress Intensity (Pm) will be calculated and shown to be less than the maximum allowed by the ASME Code.

The maximum cumulative fatigue usage factor will be calculated, and allowable years of future plant operation will be based on the maximum allowed ASME Code usage factor criterion of 1.0.

Additionally, a fracture mechanics evaluation will be performed to determine if degraded J-groove weld material could be left in the vessel, with no examination to size any flaws that might remain following the repair. Since the hoop stresses in the J-groove weld are generally about two times the axial stress at the same location, the preferential direction for cracking is axial or radial relative to the nozzle. It will be postulated that a radial crack in the Alloy 182 weld metal would propagate due to PWSCC, through the weld and butter, to the interface with the low alloy steel RPV head. It is fully expected that such a crack would then blunt and arrest at the butter-to-head 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 RPV head material are low, it will be assumed that a small flaw could initiate in the low alloy steel material and grow by fatigue. It will be postulated that a small flaw in the RPV head would combine with a large stress corrosion crack in the weld to form a radial corner flaw that would propagate into the low alloy steel RPV head by fatigue crack growth, under cyclic loading conditions associated with heatup and cooldown and other applicable transients.

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

Flaw evaluations will be performed for a postulated radial corner crack on the uphill side of the RPV head penetration, where stresses are the highest and the radial distance from the inside corner to the low alloy steel base metal (crack depth) is the greatest. Hoop stresses will be used since they are perpendicular to the plane of the crack. 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 200 ksivin for ferritic materials.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

The CEDM nozzle repair configuration is illustrated in Figures 1 and 2. The repair process description follows.

REPAIR PROCESS

a) Inspections for leakage / boric acid deposits of CEDM nozzle penetrations will be conducted during the St. Lucie Unit 1 and Unit 2 refueling outages.
b) CEDM nozzles that are determined to have through-wall leakage will be repaired. Remote machine repair processes are planned.
c) The lower portion of the thermal sleeves on PSL-1 and the guide funnels on Unit 2 will be removed by remotely operated methods to the extent practical.
d) Using a remote tool from below the RPV head, each of the leaking nozzles will first receive a roll expansion into the RPV head base metal to insure that the nozzle will not move during the repair operations.
e) A semi-automated machining tool operating underneath the RPV head will remove the entire lower portion of the CEDM nozzle to a location above the existing J-groove partial penetration weld. The machine tool will also form the CEDM nozzle weld preparation. The operation will sever the existing J-groove partial penetration weld from the CEDM nozzles. The extent of the weld preparation will insure that the new weld will not overlap the old weld.
f) The machined surface will be cleaned, and then subjected to liquid penetrant examination (PT).
g) The repair will establish a new pressure boundary weld between the shortened nozzle and the inside bore of the RPV head. A replacement lower nozzle will be welded at this time. Welding will be performed with a remotely operated machine GTAW weld head using the temper bead process. The new weld will not overlap the old weld. Minimum preheat temperature will be 50 degrees F and the welding filler metal will be ERNiCrFe-7 (Alloy 52).
h) The final weld face will be machined and/or ground.
i) The final weld will be liquid penetrant and ultrasonically examined prior to the subsequent abrasive water jet conditioning.
j) The final inside diameter surface of the CRDM nozzle and the replacement lower nozzle near the new weld and the new weld will then be conditioned by abrasive water-jet conditioning to create a final surface that is in compression, to produce optimum resistance to primary water stress corrosion cracking. A replacement guide funnel will be installed on the replacement lower nozzle.
k) A system leakage test will be performed.
l) Liquid penetrant examination acceptance criteria will be in accordance with NB-5350. Ultrasonic examination acceptance criteria will be in accordance with NB-5330.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

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

Based on the discussion above, it can be seen that it is impractical to characterize flaws in the J-groove weld by NDE and that it is impractical to show the flaws do not extend into the ferritic head base material. Nevertheless, the evaluations discussed above provide an acceptable level of quality and safety without performing flaw characterization and repetitive reexamination as required in ASME Section XI 1989 Edition, no Addenda, IWA-3300 (b), IWB-3420, IWB-2420(b) and IWB-2420(c).

V. Implementation Schedule:

This relief is implementation is scheduled, if required, during the planned fall 2002 Unit 1 refueling outage. This relief will also be implemented, if required, for any future examinations of the RPV head penetrations for leakage on either Unit 1 or Unit 2.

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

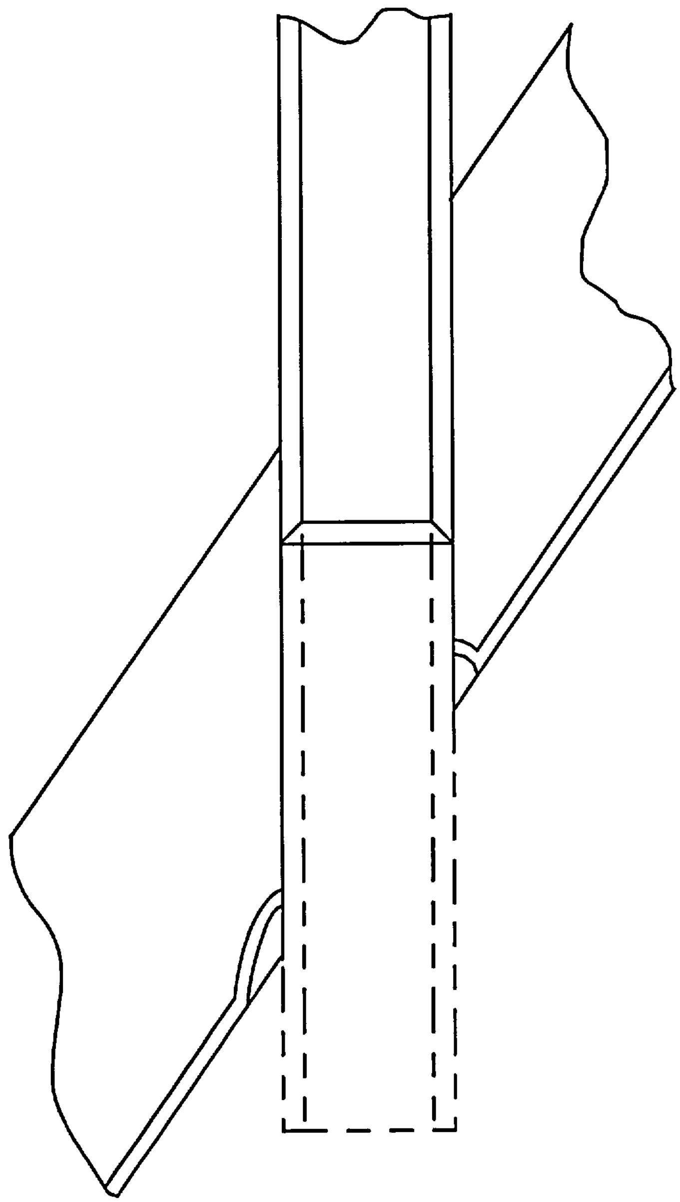

Figure 1
PSL1 and PSL2
CEDM Machining

St. Lucie Unit 1 Relief Request No. 21 Revision2
St. Lucie Unit 2 Relief Request No. 31 Revision 2

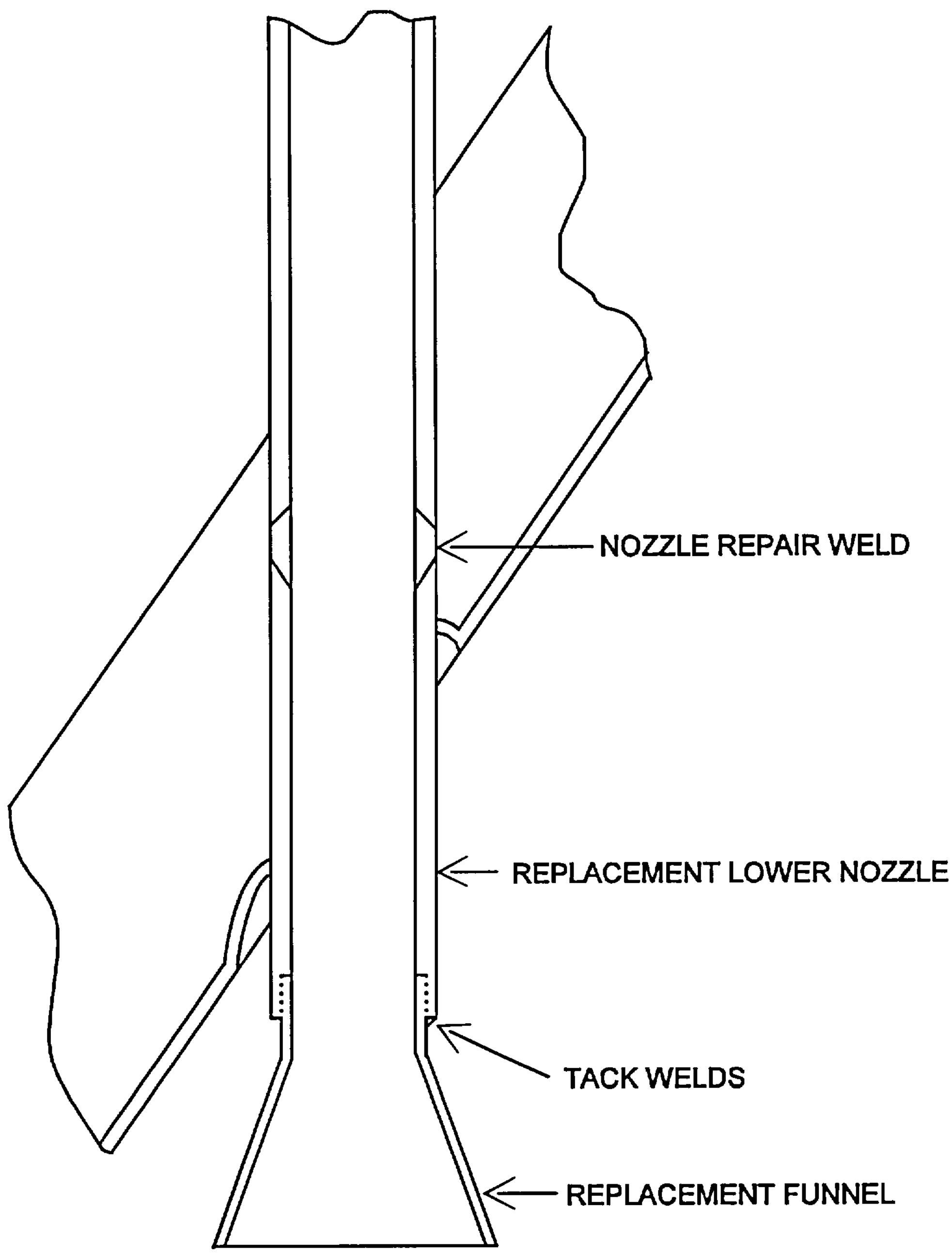

Figure 2
PSL1 and PSL2
New CEDM Pressure Boundary