FPL

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

September 27, 2002

L-2002-194
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
Second Ten-Year Interval
Contingency Relief Requests 22 and 32

Pursuant to 10 CFR 50.55a (a)(3), Florida Power and Light Company (FPL) requests approval of relief requests 22 and 32 for St. Lucie Units 1 and 2, respectively. FPL has determined pursuant to 10 CFR 50.55a (a)(3)(i) that the proposed alternatives would provide an acceptable level of quality and safety.

During the upcoming St. Lucie Unit 1 outage (SL1-18) the small bore nozzles on the reactor coolant piping hot legs will be examined for boric acid leakage and leaking nozzles will be repaired. The relief requests are submitted as a contingency to provide an alternate repair method for one cycle. The piping will not be drained during the upcoming outage; therefore, standard repair techniques cannot be used. The nozzles are welded to the interior of the hot leg piping. The proposed repair will deposit a weld at the external junction of the nozzle and the hot leg piping using a weld joint design varying from Code requirements. The evaluations performed in support of this relief 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.

During the next St Lucie Unit 1 outage (SL1-19), any nozzles that have been repaired employing the relief requested herein will be replaced. 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

A020

DEJ/GRM

Attachment

ST. LUCIE UNIT 1 RELIEF REQUEST NO. 22 REVISION 0
ST. LUCIE UNIT 2 RELIEF REQUEST NO. 32 REVISION 0

EXTERNAL WELD BETWEEN SMALL BORE NOZZLE AND REACTOR COOLANT PIPING HOT LEG

I. COMPONENT IDENTIFICATION:

St. Lucie (PSL) Unit 1 and Unit 2
Reactor Coolant Piping Nozzle Details
FPL Drawing Numbers: 8770-366, 8770-1496, 8770-3344 (PSL-1)
FPL Drawing Numbers: 2998-18705, 2998-18706 (PSL-2)

II. CODE REQUIREMENT:

Small-bore nozzles are welded to the interior of the hot leg of the reactor coolant piping. Industry experience has shown that cracks may develop in the nozzle base metal or in the weld metal joining the nozzles to the reactor coolant pipe and lead to leakage of the reactor coolant fluid. The cracks are believed to be caused by primary water stress corrosion cracking (PWSCC).

During the upcoming St. Lucie Unit 1 outage (cycle 18), FPL will examine the nozzles for evidence of leakage. Nozzles that show evidence of leakage will be repaired. The repair will be a partial penetration weld with fillet reinforcement applied to the external surface of the hot leg piping at the junction with the nozzle. The weld joint design will comply with the ASME Boiler & Pressure Vessel Code, Section III, Subsection NB, 1989 Edition, No Addenda, Figure NB-4244(d)-1, design (e).

ASME Sect. XI, 1989 Edition, No Addenda, IWA-3100(a) requires an evaluation to 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 (a)(3)(i), relief is requested to utilize alternative welding requirements to those contained in the Construction Code of Record. Relief is also requested from ASME Section XI that requires flaw characterization. The alternative requirements provide an acceptable level of quality and safety.

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

- Reference 1, Figure NB-4244(d)-1, sketch (e), dimension "λ". As defined by NB-3352.4(d) "λ" is to be 1/16 inch minimum. The proposed repair will not establish such a gap and "λ" will be zero.

- Reference 4, IWA-3300(b) and IWB-3420; requires flaw characterization based on the results of NDE. In lieu of flaw characterization, calculations will be performed to show the flaws are acceptable.

- Reference 4, IWB-2420(b) and IWB-2420(c); requires reexamination for the next three inspection periods. Since initial inspection is impractical, subsequent inspections will also be impractical.

IV. REPAIR METHOD:

Reference 4, 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."

The Construction Code of record for the St. Lucie Unit 1 reactor coolant piping is ANSI B31.7, Code for Nuclear Power Piping, Class 1, February 1, 1968 Draft Edition for Trial Use and Comment. 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 1973 Addenda.

The proposed repair will be conducted in accordance with the ASME Boiler & Pressure Vessel Code, Section III, Subsection NB, 1989 Edition, No Addenda, Reference 1.

There are two types of small-bore nozzles of concern: flow measurement nozzles and nozzles to hold resistance temperature detectors (RTD). The weld configuration for the flow nozzle is shown in Figure 1 and the weld configuration for the RTD nozzle is shown in Figure 2.

The nozzles are made of Alloy 600, SB-166. The nozzles have a 1-inch nominal outside diameter; the flow measurement nozzles have a nominal inside diameter of ½ inch; the RTD nozzles have a nominal inside diameter of 0.377 inch.

The reactor coolant piping material is SA-516 Gr 70 with internal austenitic stainless steel cladding. The pipe has a 42-inch internal diameter and a nominal wall thickness of 3 ¾ inches exclusive of the cladding.

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The nozzles are welded to buttering applied on the internal diameter of the pipe. The weld metal for both the buttering and joint between the nozzle and the buttering is Inconel 182 (SFA-5.11 Class ENiCrFe-3).

During the upcoming St. Lucie Unit 1 outage (SL1-18), FPL will examine the nozzles for evidence of leakage. Nozzles that show evidence of leakage will be repaired.

The repair will be a partial penetration weld with fillet reinforcement applied to the external surface of the hot leg piping at the junction with the nozzle. The welding will be done manually using the GTAW process, ERNiCr-3 (SFA-5.14) filler metal, preheat of 200 degrees F and no post weld heat treatment. The welding procedure specification has been qualified in accordance with ASME Boiler & Pressure Vessel Code, Section IX.

The weld joint design will comply with Reference 1, Figure NB-4244(d)-1, design (e), except for dimension "λ", the gap at the internal end of the nozzle. Dimension "λ" should be 1/16 inch minimum. The repair weld will not produce a gap between the new external weld and the internal end of the nozzle; therefore "λ" will be 0 inches. The repair configuration for the flow nozzle is shown in Figure 3 and the repair configuration for the RTD nozzle is shown in Figure 4.

During the next St Lucie Unit 1 outage (SL1-19), any nozzles that have been repaired employing the relief requested herein will be replaced.

V. JUSTIFICATION FOR USE OF ALTERNATIVE:

- Relief from Reference 1, Figure NB-4244(d)-1, sketch (e), dimension "λ".

As defined by Reference 1, NB-3352.4(d), "λ" is to be 1/16 inch minimum. The proposed repair will not establish such a gap and "λ" will be zero. The new weld configuration, a nozzle penetrating a pipe with attachment welds at both the inside and outside diameters of the pipe, will require analysis in accordance with Reference 1. An appropriate analysis has been performed, Reference 2, using a minimum weld size of ¼ inch.

The original design analyses were performed using conservative assumptions for structural interaction modeling and temperature and pressure mismatch interaction loadings. The same interaction model and stresses were used for the new analysis, except that the secondary thermal stress associated with the repair weld was superimposed upon the existing pressure, thermal, and seismic stresses at the inside and outside surface of the nozzle.

There are no additional primary loads as a result of the repair. Therefore, the primary stress criteria are met by the existing analyses.

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Reference 1, paragraph NB-3222.2, provides the criteria that primary plus secondary stress intensification must be less than 3 Sm. Normally, when a weld is performed in accordance with all of the requirements of Reference 1, that is justification for the acceptance of the weld. The weld joint will comply with Reference 1, NB-4244(d)-1, design (e), with the exception that dimension "λ" will be zero (0) inches (i.e., no gap). This exception means that an additional secondary thermal shear stress is developed in the weld that would not normally exist. Therefore, the weld is analyzed in pure shear from the thermal loading. The special stress limits of Reference 1, NB-3227.2 for pure shear note: "primary plus secondary and peak shear stresses shall be converted to stress intensities (equal to two times the pure shear stress) and as such shall not exceed the limits of NB-3222.2 and NB-3222.2." Therefore, the criteria for the weld is the same as the criteria for the nozzle; primary plus secondary stress intensification must be less than 3 Sm and the cumulative usage factor must be less than 1. As a conservative measure, the weld shear stress based on the minimum area through the Inconel weld is evaluated using both the nozzle and pipe Sm values. Similarly, the fatigue analysis is performed using the fatigue curves for both the Inconel and carbon steel metals.

The analysis, Reference 2, shows the primary plus secondary stress intensities for the weld joining both the RTD nozzles and the flow measurement nozzles to the reactor coolant hot leg piping are less than 3 Sm. The results follow:

Location	Primary + Secondary Stress Intensities
RTD Nozzle, Inside Nozzle	41,364 ksi < 3Sm (69.9 ksi)
RTD Nozzle, Outside Nozzle	53,424 ksi < 3Sm (69.9 ksi)
RTD Nozzle, New Weld (Inconel allowable)	46,043 ksi < 3Sm (69.9 ksi)
RTD Nozzle, New Weld (Steel allowable)	46,043 ksi < 3Sm (55.9 ksi)
Flow Measurement Nozzle, Inside Nozzle	37,804 ksi < 3Sm (69.9 ksi)
Flow Measurement Nozzle, Outside Nozzle	54,264 ksi < 3Sm (69.9 ksi)
Flow Nozzle, New Weld (Inconel allowable)	41,797 ksi < 3Sm (69.9 ksi)
Flow Nozzle, New Weld (Steel allowable)	41,797 ksi < 3Sm (55.9 ksi)

Analysis for cyclic operation was performed using Paragraph NB-3222.4(e) of Reference 1 which requires the cumulative usage factor to be less than 1. The intent of this repair is to last for one fuel cycle of operation. However, the fatigue analysis was performed using the full set of design transients from the original design report.

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The fatigue evaluation was performed for the weld and the outside surface of the nozzle where there is a stress concentration factor of 5 on the stress components per Reference 1, NB-3222.4(e)(2). The resultant stress intensities were calculated from the original design report. From the heat-up, cool-down and normal operating transients, the two conditions yielding the maximum range of peak stress intensity under pressure and mismatch loading were selected. These values were adjusted for seismic stress. The stress ranges are calculated based on the newly calculated stress intensities. The allowable number of cycles is based on the newly calculated stress intensities and is used to calculate the usage factor for each stress range. Finally, the cumulative usage factor is calculated. The results are as follows:

Location	Cumulative Usage Factor
RTD Nozzle, Outside	0.0401 < 1
RTD Nozzle Weld (Inconel fatigue curve)	0.0363 < 1
RTD Nozzle Weld (Carbon steel fatigue curve)	0.4765 < 1
Flow Nozzle, Outside	0.0473 < 1
Flow Nozzle Weld (Inconel fatigue curve)	0.0227 < 1
Flow Nozzle Weld (Carbon steel fatigue curve)	0.3222 < 1

The calculations have shown that the proposed weld joint design and minimum weld size are adequate to meet the requirements of Reference 1 and the proposed weld joint provides a level of safety and quality equivalent to the original design.

- Relief from IWA-3300(b), IWB-3420, IWA-3300(b) and IWB-3420

It will be impractical to characterize the subject flaws by NDE and it will be impractical to show the flaws do not extend into the ferritic piping base metal.
The repair technique will not remove any metal suspected of containing the leak and no attempt will be made to characterize the leak as required by the ASME Boiler & Pressure Vessel Code Section XI, IWA-3300. Therefore, an analytical evaluation of the crack is required as specified in paragraph IWB-3600. The analysis is to show that the flaw growth of the crack will be contained for the remaining life of the nozzle, not just for one additional fuel cycle.

The original small-bore nozzle to hot leg piping weld configuration is extremely difficult to UT from the outside diameter of the hot leg pipe. This is due to the compound curvature and distance from the outside surface to the weld, as can be seen in Figures 1 and 2. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable

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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 Alloy 182 weld metal and the carbon steel pipe increases the UT difficulty. As a clarification, this inability to characterize the flaw will continue in the foreseeable future and subsequent examinations will also be impractical.

Since the intent is to not repair this flaw, the flaw configuration must be evaluated in accordance with Reference 4, Appendix A, Analysis of Flaws, to demonstrate continued integrity of the pressure boundary during plant operation for the postulated plant life. This calculation is performed for a plant life of 60 years. A fracture mechanics evaluation has been performed, Reference 3, to demonstrate that degraded J-groove weld metal could be left in the pipe, with no examination to size any flaws that might remain following the repair. This evaluation considers an assumed double-sided crack that has propagated through the J-weld and is beginning to encroach on the carbon steel material that comprises the pressure boundary.

Acceptance Criteria

Reference 4 acceptability criteria, IWB-3610, states that the flaw is acceptable for continued service during the evaluated period if the following are satisfied:

- The criteria of IWB-3611, Acceptance Criteria Based on Flaw Size, or IWB-3612, Acceptance Criteria Based on Applied Stress Intensity Factor, and
- The primary stress limits of NB-3000 (assuming a local area reduction of the pressure retaining membrane accounting for the presence of the flaw).

This evaluation addressed the criteria of IWB-3612 and NB-3000. For IWB-3612, acceptability is shown if the applied stress intensity factors at the flaw size a_f satisfy the following criteria:

$K_I < K_{Ia}/\sqrt{10}$ (Equation 1)
$K_I < K_{Ic}/\sqrt{2}$ (Equation 2)

where:

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K_I = the maximum applied stress intensity factor for normal (including upset and test) conditions for the flaw size a_f using Equation 1 and for emergency and faulted conditions using Equation 2.

K_{Ia} = the available fracture toughness based on crack arrest for the corresponding crack tip temperature.

K_{Ic} = the available fracture toughness based on crack initiation for the corresponding crack tip temperature.

The values of $K_{Ia}\sqrt{10}$ and $K_{Ic}\sqrt{2}$ are also referred to as the allowable fracture toughness criteria. The crack depth at which the stress intensity factor equals the allowable fracture toughness is the maximum allowable crack depth.

Maximum Allowable Flaw Size

The maximum allowable flaw size was determined using the Reference 4 criteria for allowable fracture toughness. This criterion was applied at the various instrument nozzle locations analyzed and was evaluated for a range of time points throughout the transients. The time points analyzed envelope the peak stress times as well as the times with the lowest temperatures in the transient, where the allowable fracture toughness is lowest. At each of these points, the appropriate mechanical and thermal loads are used in the calculation of the maximum allowable flaw size.

For the peak stress conditions where the metal temperature is high (above 250°F), the allowable fracture toughness for normal and upset conditions is calculated from $K_{IA}/\sqrt{10}$ where K_{IA} is 200 ksi-$\sqrt{in}$ and RT_{NDT} is 60°F, and results in a value of 63.246 ksi-$\sqrt{in}$. Similarly, at the lower temperature, 70°F, the allowable fracture toughness is calculated as 13.018 ksi-$\sqrt{in}$. The maximum allowable fracture toughness for emergency and accident conditions is calculated from $K_{IC}/\sqrt{2}$ where K_{IC} is 200 ksi-$\sqrt{in}$ and RT_{NDT} is 60°F as 141.421 ksi-$\sqrt{in}$ for the high temperature condition.

Under the loading conditions considered, there is no crack depth considered that produces a stress intensity factor greater than the allowable fracture toughness.

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Normal And Upset Conditions

The principal consideration for normal and upset condition transients in this evaluation is to determine fatigue crack growth of a postulated flaw. The fatigue crack growth of the postulated flaws was calculated for normal and upset conditions per Reference 4, Appendix A, for the assumed double-sided flaw configuration. The evaluation was performed for axial and circumferentially oriented flaw configurations in the hot leg, as appropriate.

All the transients listed in the design specifications were addressed. All transients are bounded by the following two conditions. Transients not mentioned do not contribute to crack growth or present no critical conditions for possibly exceeding the fracture toughness allowable.

> Cool-down cycle and tests (hydrostatic and leak tests): The cool-down description bounds these cycles and is used for determining fatigue crack growth as well as checking that the allowable fracture toughness is not exceeded.
>
> Plant trips, loss of coolant flow, and loss of load: The plant trip is found to bound these events.

The plant trip is the primary driver of the fatigue crack growth with a slight contribution from the cool-down event. The leak test transient conditions effectively mimic the normal heat-up and cool-down loading cycle and are accounted for by increasing the required number of normal heat-up/cool-down cycles to 1050.

Normal Heat-Up/Cool-Down and Leak Test

At the low temperature condition, end-of-cool-down, is a stress intensity factor of 10.456 ksi-vin, where the allowable fracture toughness limit is 13.018 ksi-√in, based on ambient temperature (i.e., 70°F), and RT_{NDT} = 60°F. (It is noted that end-of-cool-down conditions do not control crack growth in this analysis.)

For the axial flaw case, the fatigue crack growth calculation resulted in a final crack depth of 1.001 inches after 720 reactor trips and 1050 heat-up/cool-down cycles. The axial flaw is not affected by OBE.

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For the circumferential flaw case, the fatigue crack growth calculation considered 300 OBE cycles in addition to the cycles described for the axial case. This flaw is sensitive to beam action of the hot leg, which adds to the crack growth relative to the axial flaw. However, pressure stresses are less than half those for the axial case. As a result, the circumferential flaw does not grow as much as the axial flaw. Final calculated crack depth was 0.974 inches.

The Reactor Trip Transient

The resulting initial stress intensity factor was 40.086 ksi-√in, which is below the allowable fracture toughness limit of 63.246 ksi-√in.

Emergency and Faulted Conditions

Only one emergency and faulted level transient is considered in this evaluation, the loss of secondary pressure. This transient is applied to the end-of-life flaw to check for stability in the event that it occurs.

The most severe crack direction is in the axial direction. Emergency conditions for a flaw oriented in the axial direction at peak stress conditions are investigated with the end of life flaw size. At this point, the resulting K1 value, 57.94 ksi-√in, is less than the allowable fracture toughness of 141.421 ksi-√in. Therefore, the emergency and faulted conditions meet the ASME Code requirements.

NB-3000 Primary Stress Evaluation

A crack through the existing J-groove weld would predominantly affect the peak stress intensities, which affect fatigue. Fatigue associated with the crack is adequately addressed by the crack growth evaluation. Reference 4, however, additionally requires that the primary stress limits of Reference 1, NB-3000 are satisfied for the geometry local to the crack. In the original design stress analysis, the primary stresses in the hot leg piping were calculated for a section of the hot leg, but were not specifically calculated in the immediate vicinity of this hole. Rather, in the region, Reference 1 requires that adequate pipe material exist to reinforce the hole. This Reference 1 requirement was satisfied for the existing geometry in the original design stress analysis.

Based on this, a consistent approach can be taken to address the cracked geometry. It was conservatively assumed that the crack, or multiple cracks, is

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removed. That is, it was assumed that the entire volume (defined by sweeping the crack area 360 degrees around the axis of the nozzle) is removed by grinding. It is then a simple exercise to revise the existing calculation to demonstrate that the area of reinforcement remains adequate for the existing hole area plus the flawed area assumed not to exist. Reference 3 shows that adequate area is available.

SUMMARY OF RESULTS AND CONCLUSIONS

The hot leg instrument nozzles were shown structurally acceptable per the criteria of Reference 4. These locations were demonstrated to satisfy the fracture toughness criteria at the initial flaw and the fatigue crack growth criteria associated with normal operation and upset conditions. The emergency and faulted condition criterion was also satisfied for these same locations based on the calculated end of life crack size. The fatigue crack growth was determined by the cool-down event associated with certain reactor shutdown events and testing and on reactor trips. Calculations were based on 1050 cool-down occurrences and 600 reactor trips for a 60-year lifetime.

The evaluations performed in support of this relief 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.

VI. IMPLEMENTATION SCHEDULE:

This relief is scheduled to be implemented, if required, during the Fall 2002 refueling outage planned for Unit 1 (SL1-18). This relief will also be implemented, if required, for any future examinations of the reactor coolant piping small bore nozzle connections for leakage on either Unit 1 or Unit 2.

VII. REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section III, Subsection NB, 1989 Edition, No Addenda

2. Westinghouse Electric Company LLC, Calculation Note CN-CI-02-51 Rev. 00, "RCS Hot Leg RTD Nozzle and Flow Measurement Nozzle Repair – Design Verification for St. Lucie Units 1 & 2"

3. Westinghouse Electric Company LLC, Calculation Note CN-CI-02-56 Rev. 00, "Section XI Flaw Evaluation of Florida Power and Light Units 1 & 2 Hot Leg Instrumentation Nozzles – J Weld"

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4. ASME Boiler & Pressure Vessel Code, Section IX, 1989 Edition, No Addenda

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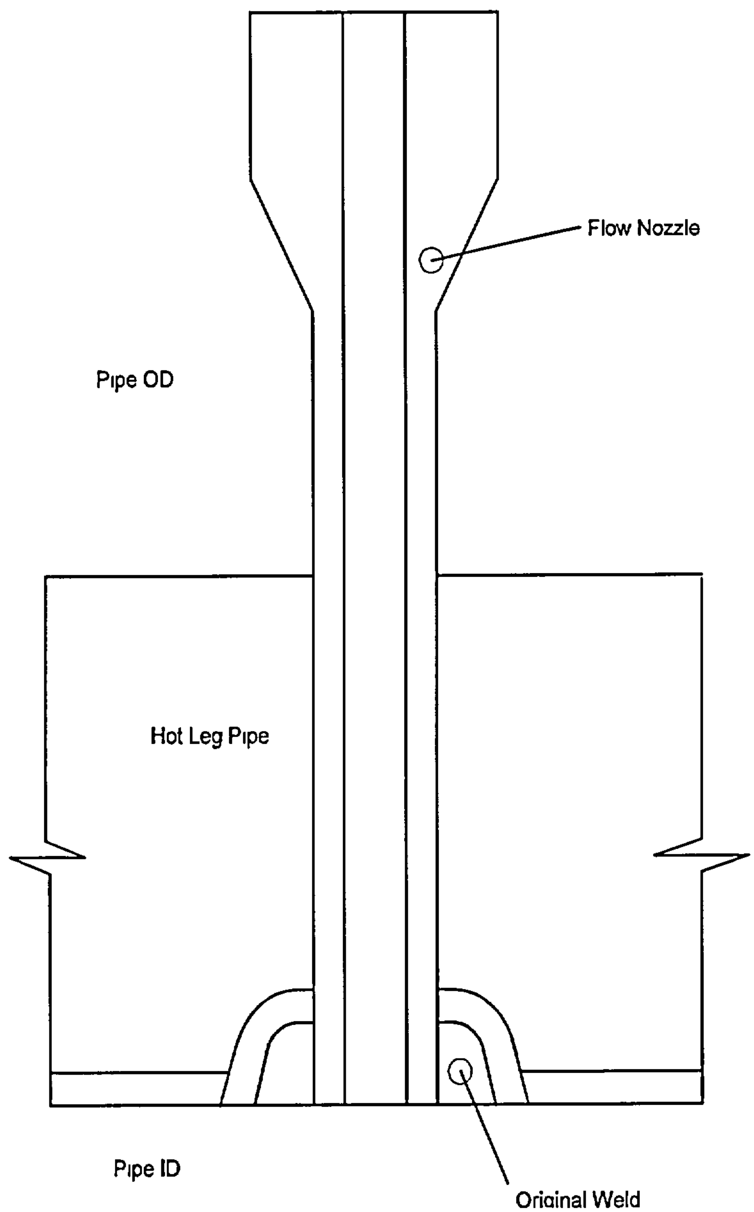

FIGURE 1
FLOW NOZZLE ORIGINAL WELD JOINT

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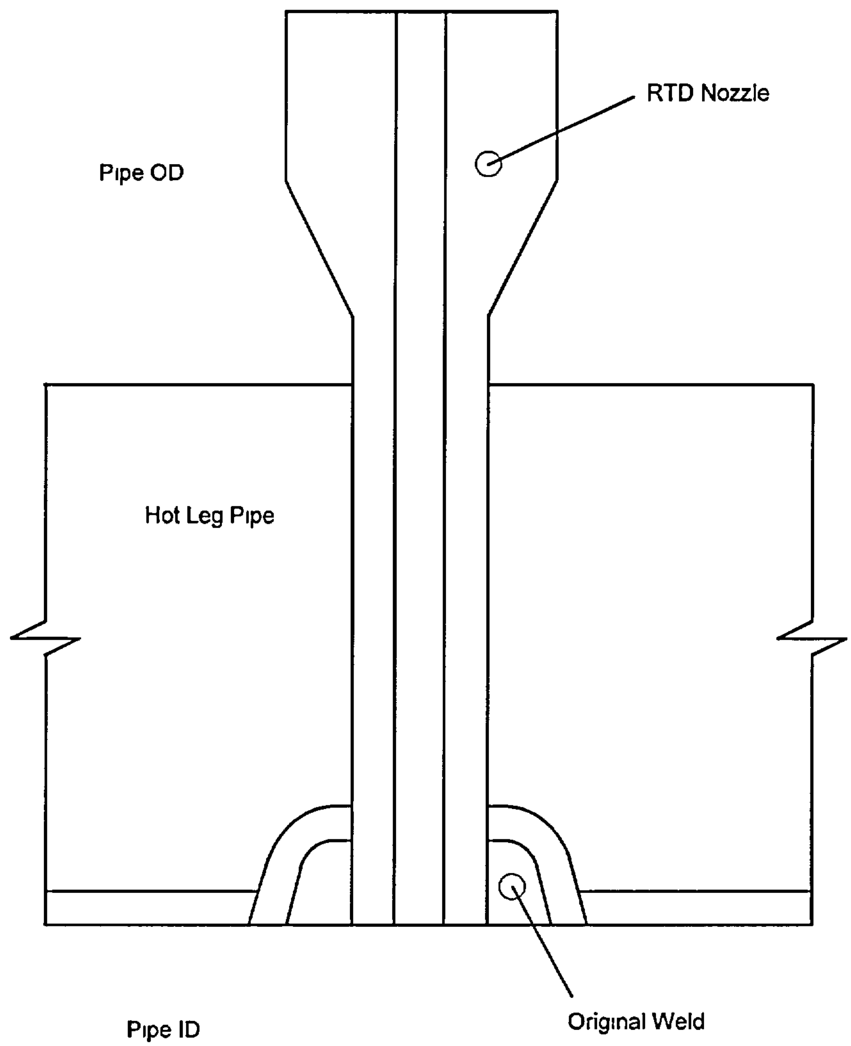

FIGURE 2
RTD NOZZLE ORIGINAL WELD JOINT

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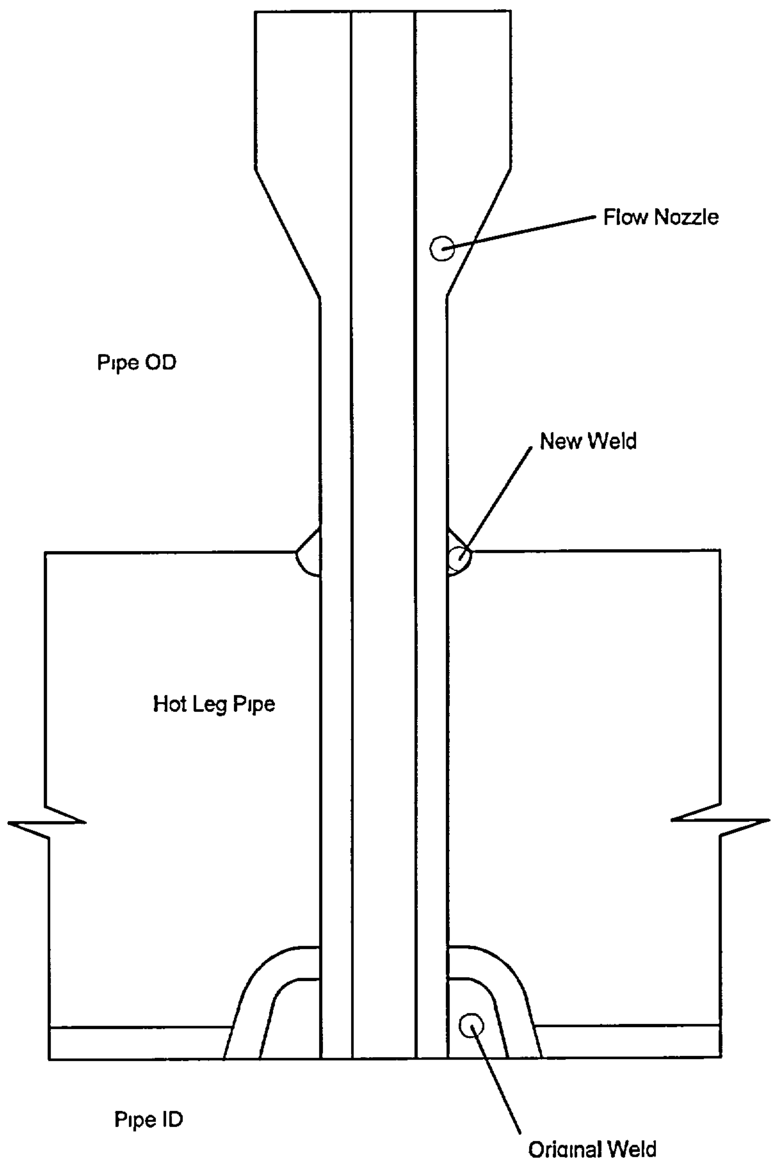

FIGURE 3
FLOW NOZZLE NEW EXTERNAL WELD

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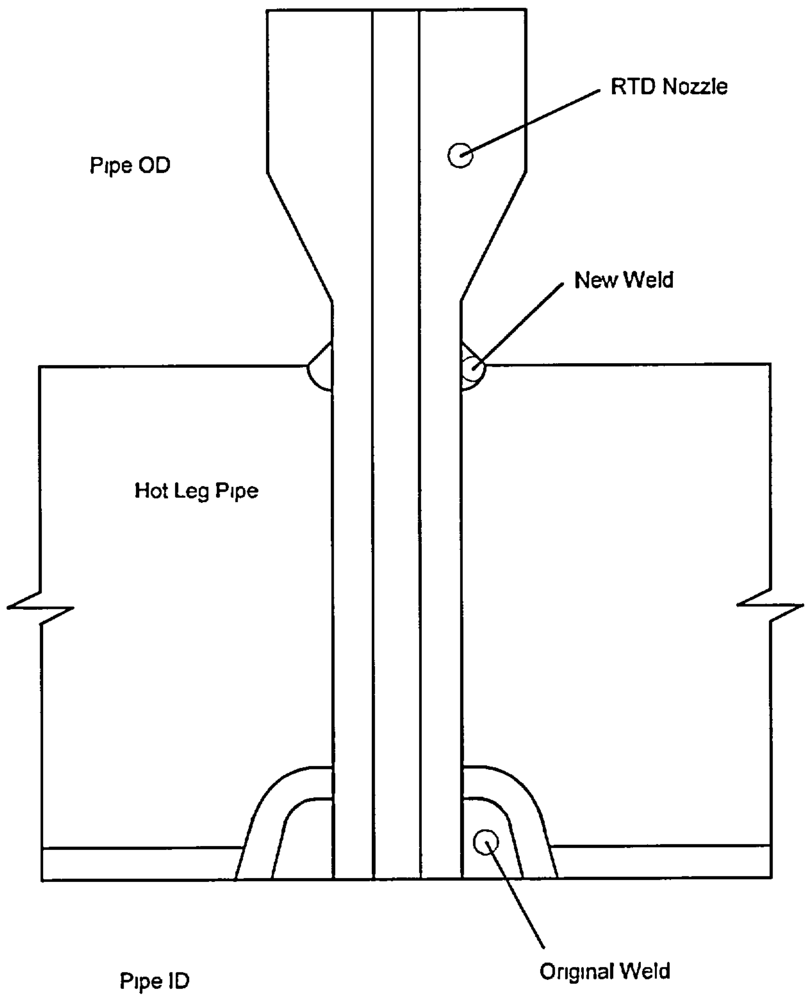

FIGURE 4
RTD NOZZLE NEW EXTERNAL WELD