UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-335/93-08 and 50-389/93-08

Licensee: Florida Power and Light Company
9250 West Flagler Street
Miami, FL 33102

Docket Nos.: 50-335 and 50-389 License Nos.: DPR-67 and NPF-16

Facility Name: St. Lucie 1 and 2

Inspection Conducted: March 10-17, 1993

Inspector: ______________________ 3/23/93
W. P. Kleinsorge P.E. Date Signed
Reactor Inspector

Approved by: ______________________ 4/12/93
J. J. Blake, Chief Date Signed
Materials and Processes Section
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope:

This special announced inspection was conducted onsite to evaluate the licensee's activities related to the leak identified March 2, 1993, in the Unit 2 Pressurizer.

Results:

This inspector identified multiple examples of failure to incorporate or failure to properly incorporate ASME B&PV Code requirements into instructions and procedures for the accomplishment of the temper bead weld repair to four Pressurizer one inch vapor space nozzles. These discrepancies went undetected by the authors and all the reviewers at the Nuclear Steam Supply System supplier, ASEA Brown Boveri/Combustion Engineering, as well as all the licensee's reviewers including the St. Lucie Facility Review Group. The end result of above discrepancies and oversights was the failure to accomplish the temper bead weld repair to the four Pressurizer nozzles in accordance with the ASME Code.

This issue discussed in Paragraph Nos. 2b(1) and 2b(2), demonstrates multiple failures relating to the control of contractors and related activities; review and approval of contractor progress at the site; understanding of the ASME B&PV Code requirements by the NSSS organization and by FPL Welding Engineers, NDE Engineers, Codes and Standards Sections, and Quality organizations.

One violation was identified concerning failures to control welding (paragraph 2c).

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*R. Boggs, JPN/ESI
*G. Bossy, Plant General Manager
*J. Brady, Mechanical Maintenance
*R. Dawson, Maintenance Manager
K. Craig, Steam Generator Program Manager
*J. Dyer, Quality Control (QC) Supervisor
*R. Englmeier, Site Quality Manager
*J. Holt, Licensing Engineer
*L. McLaughlin, Licensing Manager
*A. Menocal, Mechanical Maintenance Department Head
*D. Sager, Site Vice President
*J. Scarolia, Site Engineering Manager
*T. Skiba, ESI
*J. West, Licensing Manager
*W. West, Technical Department Manager

Other licensee employees contacted during this inspection included engineers, mechanics, security force members, technicians, and administrative personnel.

NRC Resident Inspectors

*S. Elrod, Senior Resident Inspector
M. Scott, Resident Inspector

*Attended exit interview

Acronyms and initialisms used throughout this report are listed in the last paragraph.

2. Pressurizer Leak

a. Background

In February, 1986, the Southern California Edison (SCE) San Onofre Nuclear Generating Station (SONGS) Unit 3 experienced a pressurizer vapor space leak in one of the partial penetration weld instrument nozzles. Review indicated that the SONGS nozzles were ASME SB-166 Inconel Alloy 600, Heat No. 54318. Failure analyses revealed that this heat of material had metallurgical properties that made it susceptible to Primary Water Stress Corrosion Cracking (PWSCC).

During the SCE review it was discovered that St. Lucie Unit 2 had 16 instrument nozzles of similar design and fabricated from the same heat (54318) of Inconel Alloy 600 material. These nozzles were located as follows: Pressurizer vapor space - four nozzles; Pressurizer liquid space - one nozzle; Reactor Coolant System (RCS) hot leg - five RTD nozzles; RCS cold leg - four RTD nozzles; and reactor vessel flange leak detection system - two nozzles. FPL performed an engineering evaluation to predict the time until the 16 installed St. Lucie nozzles would leak using the Arrhenius relationship. This model projects a time to failure at a given temperature from a known time to failure at a known temperature for a specific Heat of material. The model relationship is as follows:

$$\ln t_2 = \ln t_1 + Q/R[(T_1-T_2)/(T_1 \times T_2)]$$

Where:
t_1 = Time to known failure at known temperature °K T_1
t_2 = Projected time to failure at new temperature °K T_2
R = Universal gas constant (1.987 cal/mole °K)
Q = Activation energy (50 kcal/mole)

As a result of these time projections, the licensee replaced the four Pressurizer vapor space nozzles during the next refueling outage, end of cycle (EOC) 3 in the fall of 1987. Liquid penetrant examination from the I.D. prior to the removal of the nozzles indicated that two of the four nozzles were cracked, no leaks were identified. The Pressurizer liquid space nozzle was visually examined at EOC 3 (no leaks identified) and scheduled replacement at EOC 4 with the availability of needed technology. The licensee replaced the one Pressurizer liquid space nozzle and the five RCS hot leg RTD nozzles during a subsequent refueling outage EOC 4 in the winter of 1989. Remote visual examination, with a fiber optic device, of these five nozzles identified no cracks, no leaks were identified. The basis for the delay in the replacement of the hot leg nozzles was their lower operating temperature (50 °F below the Pressurizer vapor space design temperature). Because of the significantly lower operating temperature of the RCS cold leg (103 °F below the Pressurizer vapor space design temperature), the time to failure t_2 for the RCS cold leg RTD nozzles was projected to exceed the 40 year plant life, and therefore those nozzles were not replaced. The reactor flange leak detection nozzles did not represent a PWSCC concern and were not replaced because they are not normally wetted or pressurized and operate at temperature lower than the other nozzles. The ten replaced Inconel Alloy 600 Heat No 54318 nozzles were replaced with Inconel Alloy 600 Heat No 41501.

On March 2, 1993, during the heat up of the RCS for restart, with the plant in Mode 5 at 200 psig and 100 °F, the licensee discovered slight leakage emanating from under the insolation on the Unit 2 Pressurizer. Upon removal of the insulation on March 3, 1993, it was discovered that four of the four Pressurizer one inch vapor space nozzles replaced during the fall 1987 refueling outage with Inconel Alloy 600 Heat No. 41501, were leaking, none of the liquid space nozzles were leaking. The preliminary root cause was determined to be PWSCC caused by the residual stresses resulting from the installation welding applied to susceptible Inconel Alloy 600 material. The licensee inspected all of the other Inconel Alloy 600 Heat No. 41501 nozzles and found no additional leaks. There is no Inconel Alloy 600 Heat No. 41501 in Unit 1.

The licensee contracted with ASEA Brown Boveri/Combustion Engineering Nuclear Power (CE) to conduct the repair effort under the umbrella of the CE Quality Assurance (QA) program. Liquid Penetrant (PT) and Eddy Current (EC) examinations of the four vapor space Pressurizer nozzles conducted from the Pressurizer I.D. revealed one to three axial cracks in the bore of each of the four nozzles extending from approximately the root of the nozzle installation welds at the I.D. surface of the nozzles, extending axially to Pressurizer I.D. surface end of the nozzles, and continuing radially across the nozzle ends into the nozzle installation welds. CE removed by grinding the installation welds (E-NiCrFe-3) on all four nozzles, and removed the nozzles from the Pressurizer. A portion of some of the cracks remained in the nozzles after their removal. Those nozzles were sent to the CE laboratories at Windsor CT, for metallurgical evaluation. With the use of a template, the remaining nozzle installation weld metal was removed by grinding, leaving four cavities in the configuration of the original installation weld preparation. The cavities were PT examined and the remaining portion of the original cracks were removed by grinding. All of the cracks were removed within the Inconel weld metal butter layer (E-NiCrFe-3) verified by PT examination. None of the cracks extended into the P-3 base material of the Pressurizer, however some of the removal excavation cavities extended to Inconel weld metal/P-3 base material interface.

The original construction code is the ASME B&PV Code Section III 1971 Edition with Addenda through Summer 1972 (71S72). The applicable code for the pressurizer repair and nozzle installations is ASME B&PV Code Section XI 80W80 and Section III 1986 with no Addenda. The CE recovery plan was to repair weld the cavities in the Inconel buttering layer in accordance with ASME B&PV Code Section III, Paragraph NB-4622.11 "Temper Bead Weld Repair to Dissimilar Metal Welds or Buttering" to avoid the necessity of Post Weld Heat Treatment (PWHT) that would otherwise be required. The buttering layer repair would be followed by the Inconel to Inconel nozzle installation weld for the replacement nozzles, which requires no PWHT. The replacement nozzles are ASME SB-166 Inconel Alloy 690, vice Alloy 600, with the instrument nozzle safe-ends changed from ASME SA-182 F316 to ASME SA-182 F316L. There is a large body of data that indicates that both material changes will improve significantly the corrosion resistance of the nozzle/safe-end assembly. The lower stress allowable for the F316L material is above the calculated normal operating stress level in the nozzles.

b. Inspection

The inspector interviewed licensee and contractor personnel, observed work activities, and reviewed the licensee's and contractor's program, procedures and records, as described below to determine whether the Pressurizer recovery effort was being accomplished consistent with procedural and regulatory requirements.

(1) Work Activities Observed

The inspector observed preparation and welding activities for the first attempt at the temper bead weld repair to Nozzles A, B, C, and D buttering layer crack removal cavities.

With regard to the observation of work activities, the inspector noted the following:

(a) The ASME B&PV Code Section III, Paragraph NB-4622.11(c)(6), requires that the first layer of weld metal of a temper bead repair be deposited using a 3/32 inch diameter electrodes, that the weld bead crown be removed by grinding, and the second layer be deposited with an 1/8 inch diameter electrode. Contrary to the above, during the temper bead repairs to all four nozzles' buttering layer, the second layer of weld metal was deposited with 3/32 inch diameter electrodes. This is of concern because, the smaller electrode (3/32 vice 1/8 inch diameter) provided less heat input to the weldment and thus less tempering effect on the brittle martinsitic microstructure that had developed in the base material under the first layer of weld metal. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(b) Procedure CE-EP-9417-CSE-3102, Revision 0, "Procedure for Replacement of a Pressurizer Upper Instrument Nozzle at Florida Power & Light St. Lucie Unit No. 2" and ASME B&PV Code Section III, Paragraph NB-4622.11(c)(5), require that the weld area, on a temper bead repair, plus a band around the weld for five inches be preheated to a minimum temperature of 350 °F and a maximum interpass temperature of 450 °F during welding, monitored by thermocouples and recording instruments. Contrary to the above the thermocouples were not placed in locations such that they would monitor temperatures at the periphery of a five inch band around the weld. The thermocouples were actually placed at distances of 1½ to four inches from the welds. CE Procedure CE-STD-100-89, Revision 6, "Set-Up Requirements for Heat Treating Equipment", paragraph 4.8(3) requires that two thermocouples be attached around the weld area at the 3:00, 6:00, 9:00, and 12:00 positions. Two thermocouples, in point of fact, were placed at the 11:30 to 12:30 and 5:30 to 6:00 positions of each nozzle repair weld, therefore, they would not uniformly monitor the periphery of the band around the repair weld. This is of concern because the preheat temperature at the five inch periphery of the temper bead repair weld area was unknown. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(c) The ASME B&PV Code Section III, Paragraphs NB-4622.11(c)(5) and NB-4435(b) require the immediate area around the temporarily attached thermocouples be marked so the removal area can be identified after their removal for subsequent Nondestructive Examination. Contrary to the above, several of the temporarily attached thermocouples were inadvertently removed without the immediate area around those temporarily attached thermocouples, being first marked. This is of concern because there is a potential that the removal location would not be properly examined. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(d) An inadvertent arc strike near the top of the Pressurizer manway, was not reported for evaluation and repair until the next day when identified by the this inspector. This is of concern because there is a strong likelihood that the arc strike would have remained unidentified and thus uncorrected. Arc strikes have the potential of producing brittle microstructure and cracks in P-3 materials.

(2) Program Documents and Procedures Examined

ID	Revision	Title
CE-SLRM-024	3/6/93	Probable Root Cause Technical Evaluation
FPL-JPN-93-0200	3/9/93	Cracking of RCS Instrument Nozzles and Pressurizer Heater Sleeves REA SPSL-93-027-20
FPL-PC/M 096-287	9/9/87	Pressurizer Nozzle Replacement
FPL-PC/M-36-293	(R0)	Pressurizer Upper Head Instrument Nozzle Replacement
CE-EP-9417-CSE-3102	(R0)	Procedure for Replacement of a Pressurizer Upper Instrument Nozzle at Florida Power & Light St. Lucie Unit No. 2 (Engineering Procedure)

Program Documents and Procedures Examined Cont'd

ID	Revision	Title
CE-2001935-003	3/7/93	Pressurizer Upper Instrument Nozzle(s) Replacement of Top Head and Upper Level and Pressure Tap Nozzles (Traveler)
CE-EP-9417-CSE-3103	(R2)	Procedure for Weld Repair of Dissimilar Metal Welds/Weld Butter/Base Material By The "Temper Bead" Welding Process Pressurizer Upper Nozzles at Florida Power & Light-St. Lucie Unit 2 (Engineering Procedure)
CE-2001935-005	3/9/93	Weld Repair of Pressurizer Dissimilar Welds/Weld Butter/Base Material (Traveler)
CE-STD-100-89	(R6)	Set-Up Requirements for Heat Treating Equipment
CE-9392-QP-93-009	(R0)	Quality Plan
CE-EP-9417-CSE93-3104	(R1)	Procedure for Macroetching of Carbon Steel, Low Alloy Steel and Austenitic Weld Surfaces (Engineering Procedure)
CE-OP-9.4	(R12)	Liquid Penetrant Examination
CE-OP-9.1	(R7)	Visual Examination of Completed Weld Surfaces
CE-WPS-SMA-3.43-919	(R5)	(Untitled)
CE-PQR-SMA-3.43-1188	12/13/89	(PQR supporting CE-WPS-SMA-3.43-919)
CE-WPS-SMA-43.43-909	(R2)	(Untitled)
CE-PQR-SMA-43.43-102	3/5/73	(PQR supporting CE-WPS-SMA-43.43-909)
CE-WPS-GTA-8.8-910	(R8)	(Untitled)
CE-PQR-GTA-8.8-100	11/10/72	(PQR supporting CE-WPS-GTA-8.8-910)

Program Documents and Procedures Examined Cont'd

ID	Revision	Title
CE-PQR-GTA-8.8-104	1/20/82	(PQR supporting CE-WPS-GTA-8.8-910)
FPL-410-010	(R0)	Eddy Current Examination of Inconel 600 Nozzles

With regard to the review of documents and procedures, the inspector noted the following:

(a) The ASME B&PV Code Section III, Paragraph NB-4622.11(c)(6), requires that the first layer of weld metal of a temper bead repair be deposited using a 3/32 inch diameter electrodes, that the weld bead crown be removed by grinding, and the second layer be deposited with using 1/8 inch diameter electrode. CE Engineering Procedure EP-9417-CSE-3103, revision 2, "Procedure for weld repair of Dissimilar Metal Welds/Weld Butter/Base Material By The "Temper Bead" Welding Process Pressurizer Upper Nozzles at Florida Power & Light-St. Lucie Unit 2, CE traveler 2001935-005, dated 3/9/93, "Weld Repair of Pressurizer Dissimilar Welds/Weld Butter/Base Material", and CE-WPS-SMA-3.43-919, Revision 5, all specify that the first layer of weld metal of a temper bead repair be deposited using a 3/32 inch diameter electrodes, that the weld bead crown be removed by grinding, and the second layer be deposited with an 1/8 inch diameter electrode <u>maximum</u>. The word maximum used above infers, contrary to ASME Code paragraph NB-4622.11(c)(6), that electrodes of diameters smaller than 1/8 inch could be used for depositing the second layer of the temper bead repair. This discrepancy went undetected by the CE authors and all the reviewers at CE as well as all the FPL reviewers including the St. Lucie Facility Review Group (FRG). This discrepancy was identified by this inspector on March 14, 1993, after the completion of the first attempt at the temper bead repair to all four nozzles. This oversight resulted in the improper use of 3/32 inch diameter electrodes in the deposition of the second layer of the temper bead repair as discussed above. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(b) ASME B&PV Code Section III, Paragraph NB-4622.11(c)(5), requires that the weld area, on a temper bead repair, plus a band around the weld for five inches be preheated to a minimum temperature of 350 °F and a maximum interpass temperature of 450 °F during welding, monitored by thermocouples and recording instruments. CE procedure STD-100-89, Revision 6, "Set-Up Requirements for Heat Treating Equipment", paragraph 4.8(3) specifies that thermocouples shall not exceed a distance of four inches from the edge of the weld. Although CE Engineering Procedure EP-9417-CSE-310, Revision 2, and CE Traveler 2001935-005, dated 3/9/93, did address the ASME B&PV Code Section III, Paragraph NB-4622.11(c)(5) five inch requirement, CE-STD-100-89 is the working procedure for the installation of the thermocouples. This discrepancy between the Code, Engineering Procedure, and Traveler on the one hand, and CE-STD-100-89 on the other, went undetected by the CE authors and all the reviewers at CE as well as all the FPL reviewers as discussed above. This discrepancy was identified by this inspector on March 14, 1993, after the completion of the first attempt at the temper bead repair to all four nozzles. There is a strong likelihood that the incorrect incorporation of the five inch weld to thermocouple requirement in CE-STD-100-89 is the cause of the improper location of the thermocouples discussed above. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(c) The ASME B&PV Code Section III, Paragraphs NB-4622.11(c)(5) and NB-4435(b) requirement that the immediate area around the temporarily attached thermocouples be marked so the area can be identified after their removal for subsequent Nondestructive Examination, was not incorporated into any procedures provided by CE. The lack of the incorporation, into the CE site procedures, of the marking requirements for temporary attachments, went undetected by the CE authors and all the reviewers at CE as well as all the FPL reviewers discussed above. This discrepancy was identified by this inspector on March 14, 1993, after the completion of the first attempt at the temper bead repair to all four nozzles. There is a strong likelihood that the lack of the incorporation into the CE site procedures, resulted in the thermocouple areas not being marked prior to removal as discussed above. This is an example of violation 50-389/93-08-01 discussed further in paragraph 2c.

(3) Records Examined

The inspector examined Nonconformance Reports, welder qualification and qualification maintenance records, welding filler material receiving inspection and certification documentation, NDE material certification documentation, and NDE examiner qualification, certification and visual acuity records listed below.

Nonconformance Reports Reviewed

CE-2001935-1
CE-2001935-2
CE-2001935-3
CE-2001935-4

Welder Records Examined

DKD-4241	DCD-4607	WJL-1536	SFS-1209	JAB-9201
JSE-2685	JMG-6230	JRH-1846	JEL-8774	RL-1032

Welding Filler Material Records Examined

E-NiCrFe-3	3/32"	HT 53A7
E-NiCrFe-3	1/8"	HT 57A3
ER 316L	1/16"	HT S34503

NDE Records Material Examined

Penetrant	91H02K and 90L02K
Cleaner	92G01P and 92M02P
Developer	91H05K and 93A01P

NDE Examiner Records Examined

SEC	PT-II and VT-II
BHN	PT-II and VT-II
RT	PT-II and VT-II

In addition the inspector examined the weld inspection records for the first attempt temper bead welding of Nozzles A, B, C, and D, and various Tool/Material Accountability Logs.

c. Conclusion

The issues discussed in Paragraph Nos 2b(1) and 2b(2) demonstrate multiple failures relating to the control of contractors and related activities; review and approval of contractor progress at the site; understanding of the ASME B&PV Code requirements by the NSSS organization and by FPL Welding Engineers, NDE Engineers, Codes and Standards Sections, and Quality organizations. These issues also demonstrate multiple failures to accomplish the welding in accordance with the ASME B&PV Code, and are indicative of inadequate measures to control special processes including welding, which is a violation 10 CFR 50, Appendix B, Criterion IX. This violation will be identified as 50-389/93-08-01: **Failure To Provide Adequate Measures to Control Welding.**

In the areas inspected, no violations or deviations were identified except as noted in paragraph Nos 2b(1), 2b(2), and 2c.

4. Exit Interview

The inspection scope and results were summarized on March 17, 1993, with those persons indicated in paragraph 1. The inspector described the areas inspected and the findings listed below. Although reviewed during this inspection, proprietary information is not contained in this report. Dissenting comments were not received from the licensee.

(Open) Violation 50-335,389/93-08-01: Failure To Provide Adequate Measures to Control Welding.

5. Acronyms and Initialisms

ASME	-	American Society of Mechanical Engineers
B&PV	-	Boiler and Pressure Vessel
CE	-	ASEA Brown Boveri/Combustion Engineering
CFR	-	Code of Federal Regulations
DPR	-	Demonstration Power Reactor
EC	-	Eddy Current
EOC	-	End of Cycle
FPL	-	Florida Power & Light
GTA	-	Gas Tungsten Arc (Welding)
ID	-	Identification
I.D.	-	Inside Diameter
NDE	-	Nondestructive Examination
No.	-	Number
NPF	-	Nuclear Power Facility
NRC	-	Nuclear Regulatory Commission
NSSS	-	Nuclear Steam System Supplier
O.D.	-	Outside Diameter
P.E.	-	Professional Engineer
PQR	-	Procedure Qualification Record
Psig.	-	Pounds Per Square Inch Gauge
PT	-	Liquid Penetrant
PWSCC	-	Primary Water Stress Corrosion Cracking
QA	-	Quality Assurance
R	-	Revision
RCS	-	Reactor Coolant System
RTD	-	Resistance Temperature Detector
SCE	-	Southern California Edison
SMA	-	Shielded Metal Arc (Welding)
SONGS	-	San Onofre Nuclear Generating Station
UT	-	Ultrasonic
WPS	-	Welding Procedure Specification