U. S. NUCLEAR REGULATORY COMMISSION

REGION I

Report No. 50-286/82-18

Docket No. 50-286

License No. DPR-64 Priority -- Category C

Licensee: Power Authority of the State of New York

10 Columbus Circle

New York, New York 10019

Facility Name: Indian Point Nuclear Generating Station, Unit 3

Inspection At: New York City and Buchanan, New York

Inspection Conducted: October 4-8, 1982

Inspectors: for S. D. Reynolds, Jr., Reactor Engineering Inspector — 10/27/82 date

Approved By: J. Durr, Chief, M&PS — 10/27/82 date

Inspection Summary:

Inspection on October 4, 1982, at Lucius Pitkin Laboratories and October 5-8, 1982, at Site (50-286/82-18)

Areas Inspected: Announced inspection by one region based inspector to review status of failure analysis and proposed repair procedure for cracked upper shell to transition cone closure weld on four steam generators. Reviewed status of laboratory work at Lucius Pitkin Laboratory and reviewed records pertaining to fabrication and field inspection of subject welds at site. The inspection involved 7 hours at Lucius Pitkin, 28.5 hours at the site and 12 hours in the region.
Results: No violations were identified.

DETAILS

1. Persons Contacted

Power Authority of the State of New York (PASNY)

*R. T. Allen, Training Superintendent
*J. A. Schivera, Licensing Coordinator
*J. C. Brons, Resident Manager
*D. Halama, QA Superintendent
*L. Gwynn, QA Engineer
*J. McGrady, QA Manager, IP3
*S. Munoz, Technical Services Superintendent
*R. Hansler, Technical Services Superintendent
J. Leonard, Vice President and Assistant Chief Engineer/Design & Analysis
S. Zulla, Vice President PWR Nuclear Support
C. Tessmer, Project Support Engineer
P. Kokolakis, Licensing Engineer
T. A. Gado, Plant Engineer
W. Spataro, Senior Metallurgist
S. McNaughton, Materials Engineer
A. Kasuba, Materials Engineer

Lucius Pitkin Laboratories (LPL)

A. Vecchio, Vice President and Assistant Chief Metallurgist

Brookhaven National Laboratory (BNL)

C. J. Czajkowski
J. R. Weeks

*Those attending exit interview.

2. Purpose of Inspection

On March 25, 1982, a crack was discovered in a weld in the shell of one of the steam generators. The subsequent evaluation revealed potential problems in the same location of the other three steam generators. The NRC indicated it is concerned not only with the particular PASNY problems, but also with the generic implications of this failure. The repair and recovery program is of concern in assuring the safe return of Indian Point Unit 3 to power.

Pursuant to 10 CFR 50.54(f), PASNY has been requested to provide to the NRC the results of evaluations and analyses, a description of any ongoing or planned inspections and further evaluations, and plans and schedule for repair for the steam generators.

3. Scope

This inspection is a part of the review of data and procedures pertaining to the aforementioned failure analysis and repair procedure. The inspection consisted of participation in technical review meetings, review of documents pertaining to inspections conducted and fabrication details and a review of proposed repair procedures.

4. Background

The closure seam cracking problem is also reported in Inspection Report 50-286/82-05 in paragraph 10.

Portions of the subject steam generators were manufactured by various fabricators. The shell courses for the lower shell and transition cone sub-assembly were subcontracted by Westinghouse Electric Corporation (W) Heat Transfer Division (HTD) and these shells consisted of longitudinally and circumferentially welded (and post weld heat treated (PWHT)), ASME SA302, Grade B plate. The lower shell portion of the heat exchanger was completed by W HTD. The moisture separation internals were installed in the upper shell by W HTD. The completed upper shell and lower shells were shipped to W Tampa Division (WTD) for completion of the shell closure joint and internal connection of the wrapper segments. The closure weld utilized the automatic submerged arc (SAW) process on the OD side of joint followed by back gouging and shielded metal arc welding (SMAW) on the ID side of the joint. The joint was examined by magnetic particle (MT) and Cobalt 60 gamma ray panoramic radiographic (RT) methods prior to and following post weld heat treatment (PWHT). The joint was PWHT using a clam shell resistance heating assembly. The completed unit was then shipped to Indian Point 3 for installation between the primary and secondary loops. Although Code requirements only required fabrication of the shell side to American Society of Mechanical Engineers (ASME) Section III Class 2 requirements, the secondary side was designed and fabricated to Class 1 requirements.

5. Failure Analysis Meeting

On October 4, 1982, a NRC/BNL/PASNY meeting was held at the Lucius Pitkin Laboratory in New York City. Those present at the meeting were as follows:

NRC

D. Smith
T. Kenny
S. Reynolds

BNL

Dr. J. Weeks
C. Czajkowski

PASNY

C. Tessmer
W. Spataro
D. Halama

LPL

A. Vecchio

The current status of the ongoing failure analysis conducted on the boat sample and 6" diameter plug removed from the shell closure seam was reviewed. The following data was obtained:

a. The 0-270-180 half portion of the plug removed from the #32 SG was used for mechanical tests.

b. The other half (0-90-180) contains a 1½ inch weld crack on the etched face (which was previously reported on). This half of the plug also contains a 1" crack in the base metal outside the weld HAZ in the transition cone. The through-the-wall defect is contained in this half.

c. The 0-90-180 half was sliced to produce a 5/8" thick slice parallel to the face previously etched. This slice was polished and etched and shows that the previous 1" crack connects with the through-the-wall eroded hole. The crack that was out of the HAZ continues at the same general location, i.e., parallel to the original weld joint. The through-the-wall leak appears to originate in a major (ID) repair weld and to continue along the fusion zone line on the upper shell side of the weld joint. The gross erosion partially masks the metallurgical characteristics.

d. Brinnell hardness tests were made on the weld joint with the following results:

   -- Base metal (both transition cone and upper shell): 187-197 BHN.

   -- Fusion lines (both sides): 217-255 BHN.

   -- Weld metal (SMAW-ID): 187-197 BHN.

   -- Weld metal (ASAW-OD): 207-229 BHN.

e. Upper shell tensile test: (0.357" diameter) 57 ksi, 0.2% YS, 86.3 ksi UTS, 21% elongation, 39% reduction in area.

f. Charpy Vee notch (standard size) tests (average of 2) taken at ½T and tested at 76F. HAZ specimens removed with an orientation such that notch is parallel to HAZ (notched from ID side).

Location	FT-LBS
Upper Shell	76
Transition Cone	79
OD (ASAW) Weld metal	60
ID (SMAW) Weld metal	111
HAZ (cone side OD weld)	78
HAZ (upper shellside ID weld)	77

g. Fracture mechanics J integral test (converted), base metal and weld metal: 185 ksi square root inches.

h. The cracks observed are all transgranular with a 500-600F oxide and copper in the cracks. The cracks generally run parallel to the joint with the same morphology in the cracks in the weld metal, base metal, and HAZ. None of the cracks observed appear to have their origin in the "hydrogen cold cracking" portion of the HAZ. (There is no evidence to date of hydrogen induced cracking). The cracks observed range from 1/8" deep to approximately 1 1/8" deep.

i. A series of Knoop hardness traverses were made of the weld-HAZ-base metal area (converted to Rockwell C). (Straight line, every 0.020".)

Traverse I (Repair weld on ID to transition cone)

Location	Rc
Weld metal	23
HAZ	27
"	42
"	41
"	33
"	36
"	29
"	27
"	29
base metal (R_B)	98

Traverse II (OD ASA Weld Metal to Upper Shell)

Location	Rc
Weld	20
HAZ	35
"	41
"	37
"	33
"	37
"	35

Location	Rc
HAZ	27
"	27
"	30
"	25
Upper Shell	20

Traverse III (OD ASA Weld to Cone)

Location	Rc
Weld	22
HAZ	30
"	36
"	36
"	34
"	39
"	34
"	32
"	30
"	28

j. All of the cracks observed to date by LPL are transgranular and have the same morphology regardless of whether they are in the weld metal, HAZ, or unaffected base metal. The cracks observed to date are not related to weld defects. There is no indication of decarburization.

k. The major repair runs the length of the plug on the transition cone side of the joint and continues past the plug area.

l. There was no evidence of high levels of chlorides in the cracks.

m. The LPL report M-6855C-2 "Weld Coupon Heat Affected Zone Hardness Survey" was discussed. A 3.5" x 3.5" x 18" SA302 Grade B weld test assembly welded with 100F preheat and E8018-C3 electrodes was tempered at various temperatures and the HAZ hardness determined. The test assembly exhibited a known 1" deep HAZ crack which was not metallographically examined. The test assembly was cut to produce six one-inch thick transverse weld specimens. Five of the specimens were tempered for 30 hours at 800, 900, 1000, 1100, and 1200F. Four Rockwell 30 N hardness traverses were conducted on each specimen with the highest hardness reported and plotted on a hardness versus tempering temperature curve. The curve indicated the following hardness ranges (converted to Rc):

As welded	29-36
800F temper	26-38
900F temper	27-35
1000F temper	32-34
1100F temper	19-22
1200F temper	8-12

This data indicates that a temperature of 1000F for 30 hours is not sufficient to significantly reduce HAZ maximum hardness. The Laboratory Report did not indicate tne following:

-- The chemical analysis of the base metals.

-- The electrode size and joulian heat input parameters.

-- The test assembly position.

-- The hardness of the unaffected base metal.

-- The raw data for all hardness indentations.

No violations were identified.

6. Steam Generator Repair Status Meeting

On October 5, 1982, a meeting was held at IP3 with the following personnel present:

PASNY

J. Leonard
S. Zulla
C. Tessmer
P. Kokolakis
S. Munoz
R. Hansler
T. Gado
L. Gwynn
W. Spataro
D. Halama

BNL

Dr. J. Weeks
C. Czajkowski

NRC

T. Kenny
D. Smith
S. Reynolds

The following items were reviewed and discussed:

a. OD ultrasonic (UT) and ID surface magnetic particle (MT) examination results on the four steam generator shell closure welds as presented on a "cal-comp" map.

b. Summary chart on number of UT and MT indications on the subject weld joints. Layout sketches correlating the location of WTD fabrication radiographic defects to the recent UT and MT maps.

c. Review of PASNY Iridium 192 radiographs.

d. Review of results of the APTECH light enhanced radiographs.

e. Discussion of 1974 and 1978 Inservice Inspection results.

f. Status of the weld repair qualification program.

g. Review of WTD fabrication traveler data.

h. Results of PASNY HAZ tempering vs. temperature metallurgical report.

No violations were identified.

7. Document Review

The NRC inspector reviewed the following data:

a. Lucius Pitkin Report No. M-6855C-2 "Weld Coupon Heat Affected Zone Hardness Survey".

b. Helmut Thiesch Report 2271 "Typical Illustrations of Cracking and Surface Conditions at Locations of No. 6 Girth Weld No. 32 Steam Generator Unit No. 3 Indian Point Nuclear Station", June 7, 1982.

c. Lucius Pitkin Report #7154 "Circumferential Boat Sample from Steam Generator 32 IP3", June 24, 1982.

d. PASNY MT and UT charts for all four steam generators showing the relationship of indications vs. distance from "weld centerline" and circumferential location in inches from feedwater nozzle. (NRC inspector noted that the UT from OD does not closely correlate with distance from weld centerline with MT indications on the ID.

e. PASNY steam generator shell to transition weld, heat treat and inspection history chart for SG 32.

f. PASNY weld repair area charts for all four steam generators.

g. WTD Radiographic Inspection Records including disposition sheets for the transition joint, partial weld, weld repairs, RT before PWHT and RT following PWHT for all four steam generators (INGT 8003, 8004, 8005, 8006).

h. PASNY UT indication sketches for SG 32.

i. Spataro to Gado memorandum MDA-WHS-25-82, Rev. 1, dated June 7, 1982, on special electrode storage requirements for the IP3 steam generator repairs.

j. J. D. Campbell (W) to J. C. Brons letter PI & DA-82-1607 INT-82-568 dated June 23, 1982, "Quality Assurance Request for Documentation on Steam Generator Repair."

k. WTD Form N-1 Manufacturers' Data Report for Steam Generator 8004 (32).

l. APTECH Imaging Report, "Enhancement of Radiographs from Indian Point 3 Steam Generator", September 1982.

m. Photographs of ID defects on Steam Generator 32.

n. W Inspection Point Program for Steam Generator INGT 8004 (32).

o. Alloy Rods Certified Test Report for Lot K826C3A Heat 80D634 3/16" diameter E8018-C3 electrodes.

p. WTD WPS 82148QL dated September 19, 1969, and Rev. 2 dated August 11, 1970.

q. PASNY S.G. 32 Shell to Transition Weld Heat Treatment and Inspection History Chart.

No violations were identified.

8. Licensee Commitments for Further Information

At the October 5, 1982, meeting and exit interview, the licensee agreed to obtain the following information for the NRC inspector:

a. Provide more explicit information on the correlation of original W RT data, licensee RT data, W UT data and Lucius Pitkin metallurgical data on the defects in the plug area.

b. Provide additional information on the correlation of UT and MT data, and large volume ID weld repairs.

c. Provide a correlation between the apparent original fabrication defects detected with the light enhanced radiographs and the MT results.

d. Attempt to obtain more explicit information from W on the 1974 and 1978 ≥50% DAC reported ISI indications and the reasons for not investigating the 1978 50% DAC indications.

e. Metallurgical explanation for the weld repair WPS/PQR test assembly failures and the mechanical and metallurgical justification for the use of E7018 filler metal for repair welding 80 ksi minimum tensile strength base metal.

f. Provide base metal chemistry, electrode size, welding position, joulian heat input data, and remainder of hardness traverse data from the test assembly reported in the Lucius Pitkin report M-6855C-2.

g. WPS and PQR documents for the currently proposed E7018 low preheat repair procedure.

h. Statistical evaluation of the "unaffected base metal" cracked area with regard to pitting or taper mismatch weld deposition initiation sites.

i. Forwarding of the completed Lucius Pitkin report.

j. Correlation of the cracking characteristics of the weld in the area of the bead temper (unstress releived) repair on steam generator #31 in the W #9 - 12 RT areas.

k. Description of the radiation field in the repair weld area with the steam generator dry, filled with water and filled with water with additional shielding.

l. Correlation between the light enhanced RT, original RTs, IR 192 radiographs in the thru the wall leak area.

m. Information on the design and resistance element location of the WTD clam shell local PWHT furnace.

n. Information on the typical general stress analysis of the model 44 or model 51 closure seam area during regular operation and transient conditions.

o. Determine a possible explanation for the disparity between the reported ID MT defect levels of the four steam generators.

Steam Generator	MT Defects
31	109
32	203
33	53
34	60

No violations were identified.

9. Repair Welding Procedure Development

The repair welding procedure which will ultimately be employed to restore the closure weld to adequate soundness level will be based on the degree of difficulty involved, qualifications of personnel, and ALARA considerations. Knowledge of the difficulty in removing the cracks by grinding can only be obtained by actual ID surface crack grinding. Prototypic grinding should be accomplished as soon as possible to facilitate determination of the finalized repair procedures.

10. Steam Generator Tube Sleeving

The NRC inspector reviewed the following documents pertaining to the W tube sleeving program:

a. W procedure FTS-FP-433(82) Revision 0, dated September 20, 1982.

b. Steam generator radiation surveys of the cold leg side of the channel head before and after pre-sleeve cleaning.

The pre-sleeving cleaning operation was reviewed. A boric acid crystal automatically operated hydrolyzing procedure on cold leg side of all 4 steam generators has been completed. This decontamination procedure was developed by W and licensee PORC approved. The process uses approximately 4,000 psi deionized water at the nozzle with a slurry of boric acid crystals introduced at the nozzle by an eductor system. The crystals go in solution in about 5 minutes. The radiation level dropped from approximately 10R to 3R with a D/F ratio of approximately 3 in both high and low level radiation areas. The beta was essentially eliminated.

No violations were identified.

11. Exit Interview

The NRC inspector met with the licensee's representatives (denoted in paragraph 1) at the conclusion of the inspection on September 20, 1982. The inspector summarized the findings of the inspection. The licensee acknowledged the inspector's comments.