U. S. ATOMIC ENERGY COMMISSION
DIVISION OF COMPLIANCE
HEADQUARTERS

Report of Inspection

CO Report No. 219/68-3
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Licensee: JERSEY CENTRAL POWER & LIGHT COMPANY
CONSTRUCTION PERMIT NO. CPPR-15

NIAGARA MOHAWK POWER CORPORATION
CONSTRUCTION PERMIT NO. CPPR-16

(PRESSURE VESSEL REPAIR PROGRAM)

Date and Place of Visit: June 5, 1968
General Electric Company
San Jose, California

Date and Place of Previous Visit: May 24, 1968
Reactor Site
Oyster Creek, New Jersey

Inspected By: G. W. Reinmuth G. W. Reinmuth 6/12/68
Reactor Inspector (Program Standards) (Date)

Reviewed By: L. Kornblith, Jr. HR Denton for 6/13/68
Assistant Director for Technical Programs (Date)

Proprietary Information: None

SCOPE

The General Electric Company (G-E) in San Jose, California, was visited to examine metallurgical samples from the Jersey Central - Oyster Creek and the Niagara Mohawk - Nine Mile Point reactor pressure vessels. Other details of the vessel repair programs were also discussed. L. Porse from the Division of Reactor Licensing (DRL) and P. Patriarcha, Oak Ridge National Laboratory (ORNL), acting as consultant to DRL, accompanied the inspector.

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SUMMARY

Examination of stub tube metallurgical samples removed from the Oyster Creek reactor vessel did not disclose any unexpected results. The base material was observed to be sound. The samples were taken from two stub tubes in the center of the vessel, one of which included the first control rod housing to stub tube field weld. Both had been clad. Improvements are being incorporated in the welding procedure for the field welds because of the poor quality observed in the above sample.

G-E has decided to clad all vessel nozzle safe-ends made of 304 stainless that are accessible. Similar safe-ends on smaller nozzles that are not accessible will be cut off and replaced. Those in the vessel head will be left as is.

An additional mechanical support structure is being designed to reduce the consequences of failure of the stainless forging incorporated in the core shroud support. Metallurgical samples from this piece also showed corrosive attack. Final details of this fix will be described in a forthcoming license amendment.

Metallurgical samples from the Niagara Mohawk - Nine Mile Point vessel stub tubes did not show the intergranular corrosion attack observed at Oyster Creek.

DETAILS

I. Participating Personnel

The following attended the meeting and participated in the discussions:

W. R. Smith, Jr., Consulting Engineer, G-E
A. M. Hubbard, Manager, Materials Engineering, G-E
W. L. Walker, Engineer, Materials Engineering, G-E
R. H. Huggins, Oyster Creek Project Engineer, G-E
M. Kudlick, Project Engineer, G-E
G. M. Gordon, Materials Science and Development, G-E
W. R. Schmidt, Jersey Central Consultant, MPR Associates
P. Patriarcha, DRL Consultant, ORNL
L. Porse, C&C Technology Branch, DRL
G. W. Reinmuth, Technical Support Branch, CO

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II. Meeting Agenda

The meeting with G-E and Jersey Central representatives consisted of a semiformal presentation covering the entire cracking problem experienced at Oyster Creek and the repair program. The specific subjects discussed were presented according to the outline enclosed with this report as Appendix A. Since much of the information presented has been documented previously, only new information will be described. Following the presentation, metallurgical samples from both Oyster Creek and Nine Mile Point vessels were directly observed with the aid of a microscope.

III. Results of Observations

A. Oyster Creek Stub Tube Samples

The principal purpose of the San Jose visit was to directly observe metallurgical samples removed from two of the Oyster Creek vessel stub tubes, Nos. 27-26 and 27-30. Tube 27-26 had been clad and included the stub tube to control rod drive housing field weld. Both operations had been performed according to procedures qualified for use in the actual repair of the vessel. Approximately the top two inches of tube 27-26 had been cut off, including the entire stub tube to housing field weld. Tube 27-30 had been clad only and the top one inch removed for sampling.

The intent of direct observation was to determine if welding had any effect upon the sensitized 304 stainless stub tube material. Observations of several samples at magnification up to 400 diameters did not disclose any signs of degradation of the stub tube material. No cracking under the welds was noted, bonding of the clad looked good and the grain structure throughout the sample appeared normal for sensitized material.

Mechanical and chemical properties of the two stub tubes were compared with normal 304 material. All were within allowable ranges. Miniature bend specimens from tubes 27-26 and 27-30 were satisfactory.

Detracting from an otherwise satisfactory situation as observed from the samples, was an obviously faulty field weld on tube 27-26, caused by lack of fusion mostly in the area of the root pass. This was the first field weld to be performed in the vessel utilizing the newly developed automatic welding machine. Samples of qualification welds, including cut cross sections, had been observed previously and were sound. The faulty weld was stated to have been performed in compliance with the procedure.

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The following reasons were offered by G-E as to the cause of the poor weld:

1. The weld and metallurgical sample from this particular tube was requested upon relatively short notice (about ten days). This, according to G-E, resulted in less attention to detail than would normally be given.

2. A leak in the helium purge line to the welding machine contributed to heavy oxidation in the root of the weld. The leak was not discovered until after the weld was complete.

3. The welders used a discontinuous TIG tack weld for a root pass. This also contributed to the observed heavy oxidation.

To obtain better welds in the future, the procedure has been modified in that the TIG root pass will be continuous and will use a heavier filler wire. This is expected to result in a higher heat input which in turn should promote improved fusion. The leaking helium purge line was also replaced. A sample, cut from a requalification weld was given to the inspector and is sound.

A fallout from the faulty weld was further verification of the adequacy of the ultrasonic testing (UT) method developed for examining the field welds. Prior to weld sectioning, the defects were charted by UT. The charted defects were then compared against the observed flaws and found to be in close agreement, both in size and location.

In discussing the value of UT testing, G-E was questioned concerning the acceptance standard to be employed on the field welds. According to W. R. Smith, the reject level has not been established. He inferred that it could be rather loose since the depth of the field weld was approximately double what it needs to be to achieve the design strength. This inspector pointed out that for normal vessel seam welds, any linear indication longer than 3/4" required repair; thus, one would expect this standard to also apply to the stub tube welds as a minimum requirement. Since Mr. Smith did not appear to agree, he was advised that he should be prepared to defend his position on a technical basis.

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B. Welding Over Cracks

A controversial question concerning the repair by cladding of the stub tubes has been the unknown effect of applying the cladding over undetected cracks and the effect of trapped corrodents in such cracks under the weld.

To evaluate this area, G-E induced corrosion cracking, similar to that observed at Oyster Creek, in sensitized stainless 304 samples. The samples were also dye tested to further simulate the real conditions. 308L cladding was then applied to the samples over the cracks, thus sealing in the corrodents.

Examination of the samples showed the weld cladding fused the cracked areas into the weld metal to a depth of approximately .050". The weld metal itself was sound and showed no deleterious effects from the absorption of corrodents.

C. Adequacy of Clad Repair

To support their conclusion that cladding is an adequate repair of the stub tube problem, G-E cites the following facts:

1. Any crack greater than .010" will be detected by the dye penetrant test used. This has been correlated by the metallurgical testing program and demonstrated through numerous repetitive dye tests.

2. All detected cracks are removed.

3. If for some unknown reason a crack is overlooked, weld cladding will fuse any crack down to .050" in depth into the weld metal.

4. If a crack greater than .050" were overlooked, the clad would seal the crack from exposure to an oxygen environment, thus inhibiting any corrosive attack.

5. The use of 308L as the clad material provides a high resistance to intergranular stress corrosion as shown by recent G-E corrosion tests.

6. Actual metallurgical and mechanical tests of the as-applied cladding demonstrate a satisfactory condition in both stub tube and clad material.

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IV. Repair of Sensitized 304 Areas - Oyster Creek

A. Nozzle Safe-ends

Samples removed from the vessel nozzle safe-ends show some evidence of intergranular attack although to a lesser extent than observed on the stub tubes. In view of these observations, G-E has made the following decisions.

1. All ten of the large recirculation system nozzle safe-ends will be clad.

2. The two nozzles to the emergency condenser will be clad if sufficient accessibility exists. If not, the safe-ends will be replaced.

3. All other 304 stainless safe-ends on smaller nozzles in the vessel (3 total) will be replaced.

4. Three small nozzles in the vessel head having 304 safe-ends will not be replaced at this time, since these can be replaced, if found necessary, after operation begins.

B. Shroud Support Skirt

One sample from the stainless steel forging, which is part of the shroud support structure, also showed evidence of intergranular attack. Rather than attempt to clad in place, G-E is proposing to add additional mechanical support. A sketch of the proposed turn-buckle design is enclosed as Appendix B. According to G-E, the forged ring could crack in any direction or dissolve without causing a problem. The sketch should not be considered final as design details and stress analyses were still in progress. An amendment covering this repair will be submitted in about three weeks.

V. Niagara Mohawk - Nine Mile Point Plant Sample Review

Another purpose for visiting G-E was to directly observe metallurgicial samples removed from stub tubes in the Nine Mile Point reactor vessel. 56 specimens were made available, of which 6 were observed under a microscope. No evidence of intergranular corrosive attack was observed

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in any of the samples. The grain structure looked normal in all areas, weld bonds were sound and the sensitization of the material was similar to that observed on Oyster Creek samples. From the evidence provided by these samples, G-E's conclusion that there has been no intergranular corrosive attack at the Nine Mile Point plant up to the time the samples were removed, appears to be correct.

The inspectors were informed that the Nine Mile Point vessel will be cleaned with a TSP solution, hydrostatically tested and dye tested. If no cracking is observed after these operations are completed, cladding of the stub tubes would be considered unnecessary.

Enclosures:
1. Appendix A
2. Appendix B
3. Appendix C

APPENDIX A

A E C PRESENTATION

6-5-68

WLW I GENERAL DESCRIPTION - Oyster Creek Vessel

(Slide #1) Vessel cross section with furnace sensitized 304 indicated

(Slide #2) Stub tube cross section

WLW II PENETRANT AND ULTRASONIC EXAMINATIONS AND RESULTS

(Slide #3) Summary of PT & UT on stub tubes

(Slide #4) Sequential PT tests on 5 stub tubes

A. Description of distribution of PT indications - furnace sensitized 304

B. Working below detection limits intended for PT

WLW III SAMPLING PROGRAM

(Handout sheets)

WLW IV METALLOGRAPHY

A. Stub Tubes

1. Shop weld area

(Slide #5 - Tube 07-42)

2. Tube surface

(Photo & Photomicrograph

3. Field weld

(Photo)

B. Other Components

1. Safe Ends

(Slide #6 - As received & PT)

(Slide #7 - Micros)

WLW IV (B. 2. (Continued)

2. Shroud Support Ring

(Slide #8 - Schematic)

(Slide #9 - As received & PT - #16)

(Slide #10 -Micros on #15 & #16)

WLW V LABORATORY WORK

A. Source of corrodent

(Slide #11 -)

B. Present practices to exclude corrodent in future.

C. Comparison of stub tube and normal 304 chemical and mechanical properties.

(Slide #12)

D. Sensitivity of PT examination

(Amendment #29 + photos)

E. Welding on pre-cracked 304

(Slide #13 - PT on cracked plate)

(Slide #14 - Micro on crack)

(Slide #15 - Weld and Micro on clad)

F. Rationalle on repair

(Slide #16)

(Wilde's calculations)

WLW VI NINE MILE POINT AND TARAPUR INSPECTIONS & RESULTS

A. PT results (Slide)

B. Metallography

C. Explanation

WLW VII OYSTER CREEK FIX

A. Alternatives and reasons for choice

(Slide #17)

B. Stub Tubes

1. Grind and clad - Field sample

(Slides 18, 19, 20, 21, 22)

C. Field welds

1. Remove and reweld

(Samples)

D. Shroud support ring

1. Redundant mechanical support

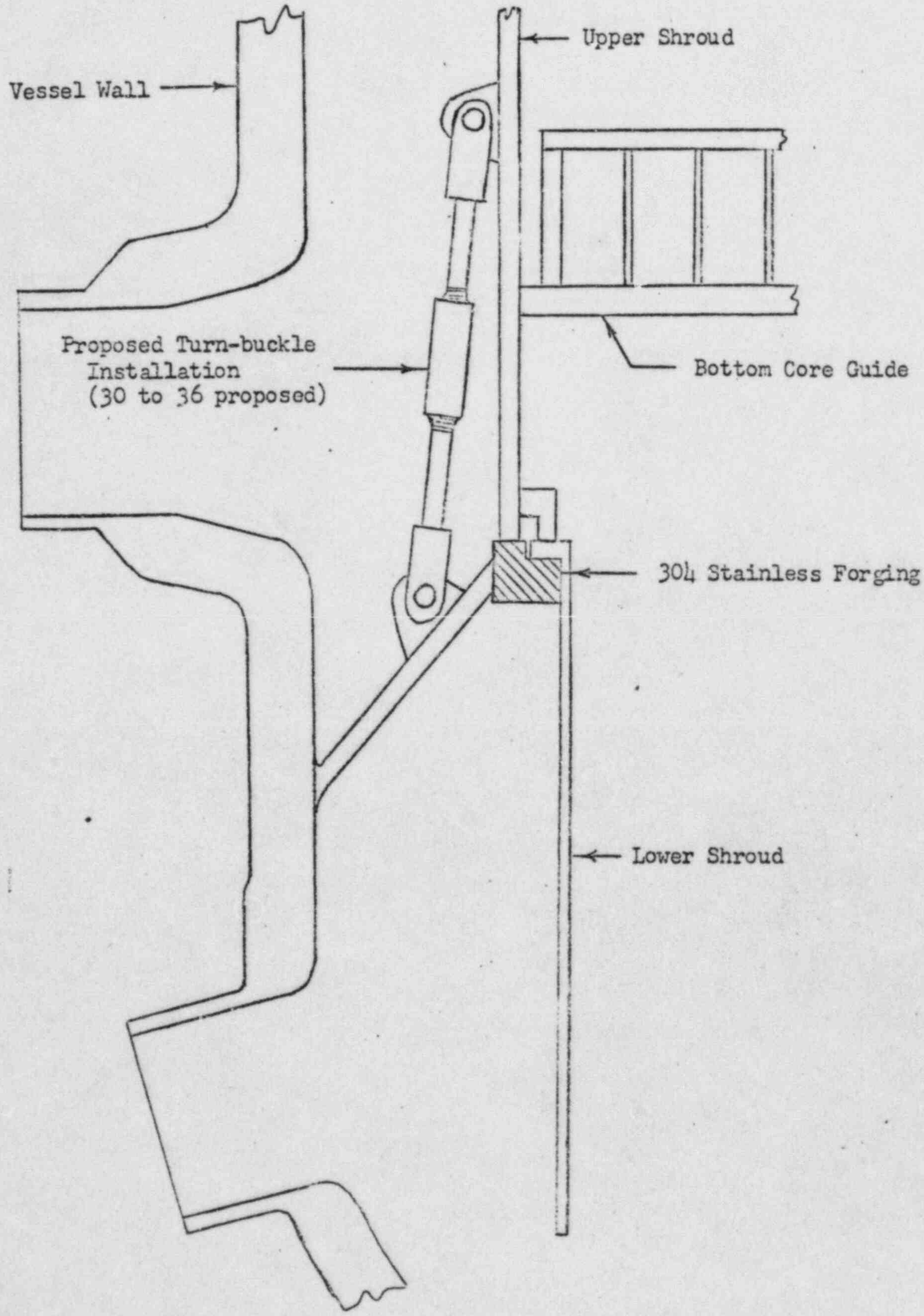
E. Safe ends

1. Grind and clad large ones

2. Replace small ones

WRS VIII EXAMINE METALLURGICAL SAMPLES, IF TIME IS AVAILABLE

APPENDIX B



Upper Shroud
Vessel Wall
Proposed Turn-buckle Installation (30 to 36 proposed)
Bottom Core Guide
304 Stainless Forging
Lower Shroud

APPENDIX C

SAMPLE PROGRAM - OYSTER CREEK VESSEL REPAIR

Sample No	Location	Description Specimen	Analysis Performed	Summary Results	Reported In
1	Stub Tube 51-34	Shop Weld Area (Uphill)	M, P, ED, EM, X	Indicated IGC And Normal Base Material	Amd. 29 - Fig. 1 Amd. 35 - Fig. 7
2	Stub Tube 03-34	Shop Weld Area (Uphill)	M	Indicated IGC	Amd. 29 - Fig. 2 Amd. 35 - Fig. 8
3	Stub Tube 03-32	Slab Sample Through Field Weld	M, B, P, EM, H	IGC + Indications Of Dye Penetrant - Other Tests Normal	Amd. 29 - Fig. 4 Amd. 35 - Fig. 9
4	Stub Tube 03-34	Shop Weld Area (Downhill)	M, C	Showed Minor Flaw Which Could Be Interpreted IGC - Chemistry Normal	Amd. 29 - Fig. 8
5	Stub Tube 39-46	Slab Sample Through Field Weld	M, F	Showed Defects in F.W. Low Ferrite (.02)	Amd. 29 - Fig. 7
6	Stub Tube 07-42	Slab Sample Through Shop Weld And Field Weld	M, F	IGC At Shop Weld + Lack Of Fusion In F.W. - Low Ferrite in Tube	On File
8	Stub Tube 03-22	Shop Weld Area After Repair Weld	M	Showed Repair To Be Sound No Cracking	Amd. 29 - Fig. 6
10A	Stub Tube 43-46	Slab Sample Through Field Weld	M	Sound Material	On File
10B	Stub Tube 31-02	Field Weld To Just Above Shop Weld	M	Sound Material	On File
11	Stub Tube 27-26	Slice Through Tube And CRDH	M, C, B, Co	C, Co Not Done M, B-Normal	New

Sample No	Location	Description Specimen	Analysis Performed	Summary Results	Reported In
12	Stub Tube 27-30	Slice Through Tube	M, C, B	M, B, - Normal Not Done Yet	New
13A	Safe End Recirc Inlet Loop D	Inside Dia Through 1/32 Flaw	M, C, B, Co	C, Co Not Done M, B - Normal	New
13B	Safe End Recirc Loop	Inside Dia At Shop Weld Junction	M, B		Planned
14A	Safe End Recirc Outlet Loop C	Outside Dia (No Indications)	M, B, Co	Cut But Not Evaluated	Planned
14B	Safe End Recirc Loop	Outside Dia At Shop Weld Junction	M, B		Planned
15	Shroud Support Ring	Wedge Through Indication At Bottom 340°-0°	M, B	IGC At Flaw B - Normal	New
16	Shroud Support	Wedge Through O.D. Grind Out And Clear Area	M, B	Weld Defect (Checking C.E. Process)	Planned
17	CRD Housing Bottom Flange	A-1 Position - Housing Subjected To 130 PPM Cl	M, C, B, Co	M, B - Normal C, Co - Not Done	Planned
18	Stub Tube	"Powder" Removed By Brushing After Overlay	C	Various Metal Oxides Normal For Welding	New

May 6, 1968