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October 9, 1984

Mr. Walter A. Paulson, Acting Chief
Division of Licensing
Operating Reactors Branch No. 5
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Paulson:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
License No. DPR-16
Response to Generic Letter 84-11

GPUN has completed developing a piping inspection program for the Cycle 11 refueling outage. The attached TDR No. 571 discusses scope of inspections, examination criteria, repair methods, mitigating actions, leak detection and leakage limits. Systems to be inspected include Recirculation, Reactor Water Cleanup, Shutdown Cooling, Core Spray, and Isolation Condenser.

As we discussed at our meeting August 29, 1984, TDR No. 571 is being submitted according to a mutually agreed schedule. The time period for submitting a response to Generic Letter 84-11 began with the submittal of TDR No. 580, Revision 0 which discussed cracking in the Isolation Condenser System.

Please contact Mr. Drew Holland of my staff at (609)971-4643 in the event any comments or questions arise.

Very truly yours,

Peter B. Fiedler
Vice President and Director
Oyster Creek

PBF/dam
Attachment

cc: Dr. Thomas E. Murley, Administrator
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TECHNICAL DATA REPORT

TDR NO. 571	REVISION NO. 0
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Reactor Coolant System Inspections For IGSCC - 1985/86 Outage

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ABSTRACT:

Purpose
This report is GPUN's response to the NRC's Generic Letter 84-11 regarding inspections of BWR Stainless Steel Piping.

This report defines the scope of inspections to be performed on the reactor coolant system piping during the next scheduled outage. The purpose of the inspections is to detect the the presence of intergranular stress corrosion cracking in stainless steel weld joints.

Also defined are the examination criteria, repair options, mitigating actions, leak detection, and leakage limits.

SUMMARY OF KEY POINTS

Systems to be Inspected
Recirculation, reactor water cleanup, shutdown cooling, core spray, isolation condenser.

Number of Welds to be Inspected
The initial sample size is approximately 75. Increased sampling is specified should cracks be detected.

Examination Criteria
Procedures and personnel will be qualified to the requirements of IE Bulletin 83-02.

Repair Options
The three repair options for cracked welds are: 1) weld overlay, 2) spool piece replacement, and 3) system piping replacement.

Mitigating Action
Mitigating actions are being considered to minimize the potential for IGSCC. The actions being considered are: 1) induction heating stress improvement and 2) hydrogen water chemistry control.

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1.0 INTRODUCTION

1.1 Purpose

This document is GPUN's response to the NRC's Generic Letter 84-11, "Inspections of BWR Stainless Steel Piping" [1].

Augmented inspections of Reactor Coolant System (RCS) piping for intergranular stress corrosion cracking (IGSCC) will take place during the next scheduled outage (1986). This document identifies the planned actions for the following:

a) Systems to be inspected

b) Sampling basis for establishing the quantity of welds to be inspected for:

   1. Initial inspections
   2. Additional inspections should cracks be detected during the initial examinations

c) Basis for selecting specific welds for inspection

d) Inspection criteria

   1. Methods
   2. Procedure qualification
   3. Personnel qualification

e) Repair methods for cracked welds

f) Mitigating actions for uncracked welds

Additionally, leak detection and leakage limits are discussed.

1.2 Background

IGSCC has been a recurring problem in Boiling Water Reactor (BWR) stainless steel RCS piping. It has caused numerous plant shutdowns and extensive repair/replacement programs.

The utilities, EPRI, and the NRC are involved in extensive programs for detecting and preventing IGSCC. This report addresses GPUN's planned actions for detecting and minimizing IGSCC.

1.3 Scope of Inspections

Five systems are to be inspected:

1) Recirculation (5 loops)
2) Reactor water cleanup
3) Shutdown cooling
4) Core spray
5) Isolation condenser

See Table I for the approximate number of welds in each system and the extent of the inspections.

These systems have been generically susceptible to developing IGSCC.

1.4 Number of Welds to be Inspected

The initial sample size is approximately 75 welds.

The sampling basis for initial inspections is as follows:

a) 20% of the welds previously inspected,

b) 20% of the welds not previously inspected, and

c) 100% of the weld overlays in the Isolation Condenser system.

The specific welds to be inspected will be selected based on evaluation of the following:

1) Field experience at similar plants
2) Weld history (repaired welds, shop or field welds)
3) Carbon content
4) Damage Index calculations
5) Previous inspection results

Additional sampling is required if cracks are detected. The number of additional welds is based on the system and location within the system.

1.5 Examination Criteria

Procedures and personnel will be qualified to the requirements of IE Bulletin 83-02 [6] and the GPUN NDE Programs Manual.

1.6 Repair Options

Three options exist for repairing welds that are determined to have cracks. They are:

1) weld overlay,
2) spool piece replacement, and
3) system piping replacement.

1.7 Mitigating Actions

1.7.1 Induction Heating

Induction heating stress improvement (IHSI) is being evaluated for welds in the systems identified above. The criteria for evaluation are:

1) field experience at similar plants,
2) if the weld has been repaired, and
3) calculations, using EPRI-supplied methods, to estimate whether or not the welds are susceptible to developing IGSCC.

1.7.2 Hydrogen Water Chemistry

Hydrogen water chemistry control is another means of minimizing the potential for IGSCC. But, full implementation during the 1986 outage will not be possible because of the lack of sufficient supporting data.

GPUN is investigating the performance of limited testing following the 1986 outage.

2.0 Scope of Inspections

2.1 NRC Recommendations

2.1.1 Systems to be Inspected

The NRC, in Generic Letter 84-11, recommends performing inspections of stainless steel welds in systems, out to the second isolation valve, that are generically susceptible to developing IGSCC. Generally, these systems are identified as having a pipe diameter of 4-inches and greater and operate at 200°F or higher. But, licensees must use field experience as part of the assessment to select systems for inspection.

2.1.2 Inspection Sampling

The NRC recommends inspection of:

2.1.2.1 Welds not previously inspected: 20% but not less than 4,

2.1.2.2 Welds previously inspected: 20%, but not less that 2,

2.1.2.3 All unrepaired cracked welds,

2.1.2.4 Weld overlays where the crack length exceeded 10% of the pipe circumference, and

2.1.2.5 Welds treated by induction heating stress improvement (IHSI) methods that were not post-treatment ultrasonic test accepted.

2.2 GPUN Position

This section provides the scope of inspections that will take place during the next scheduled outage. The next outage is currently scheduled to begin in April 1986.

2.2.1 Systems to be Inspected

The systems and their respective piping diameter(s) are listed in Table I.

2.2.2 Inspection Sampling

The sampling basis for initial inspections will be as specified in Generic Letter 84-11. The initial sample size will be approximately 75 welds.

For each pipe size 4-inches and greater in diameter in each system listed in Table I, sampling for initial inspections will be as follows:

a) Piping Welds

1. Welds previously inspected - 20% but not less than 2, and

2. Weld not previously inspected - 20% but not less than 4.

b) Weld Overlays

There are 18 weld overlays on the Isolation Condenser system piping outside containment [3].

The assumption used to design the overlays was that, at each location, a through-wall crack was present for 100% of the circumference. Therefore, since no credit was taken for the remaining wall ligament, inspection of the pipe beneath the overlay is not technically meaningful. Each overlay will be nondestructively examined to detect relevant service-induced discontinuities.

There are no unrepaired welds with detected cracks or any welds treated with induction heating at Oyster Creek.

2.2.3 Basis for Selection of Welds

This section describes the criteria to be evaluated to select specific welds for inspection.

2.2.3.1 Welds not previously inspected

a) Field experience at similar plants

b) Weld History

   1) Field weld

   2) Shop weld

   2) Repair history

c) Carbon content

d) Damage Index Calculations (see EPRI Reports NP-2807-LD [4] and NP-2808-LD [5]). Appendix A provides a brief description of the Damage Index and its application.

2.2.3.2 Welds Previously Inspected

Previous inspection results plus the criteria of 2.2.3.1.

2.2.4 Additional Inspections

Should cracks be detected during the initial inspections, additional welds in the same system will be inspected. An additional sample size equal to the initial sample size will be inspected.

For the recirculation system, the same weld(s) in the other four loops will be included in the additional sample. If additional cracking is detected, 100% of the remaining butt welds in the system will be inspected.

The basis for these sample sizes for additional inspections can be found in IE Bulletin 83-02 [6].

3.0 EXAMINATION CRITERIA

3.1 Examination Methods

The primary method of examination will be ultrasonic testing (UT). The UT detection procedure shall have been demonstrated effective in accordance with IE Bulletin 83-02.

Other NDE methods will be used, as necessary, to complement or verify the UT findings.

3.2 Examiner Qualifications

All Level II and III UT examiners will be qualified to IE Bulletin 83-02 requirements and the GPUN NDE Programs Manual. All UT examiners, including Level I, will show field performance capability.

3.3 Examiner Availability

GPUN does not anticipate any problems with examiner availability. Before the next outage begins, we will have appropriate personnel either hired or contracted.

Additionally, we are investigating the use of automated equipment for performing the examinations. If automated equipment is used, the number of personnel required to perform the examinations will be significantly reduced. Total personnel exposure to radiation will also be reduced.

4.0 REPAIR METHODS

This section describes the various repair options for cracked welds.

4.1 Spool Piece Replacement

The defective weld and adjacent piping material can be cut out of the system and replaced with material conforming to the latest issue of NUREG-0313 [2] and current welding techniques including Last Pass Heat Sink Welding (LPHSW) designed to reduce susceptibility to IGSCC. See Section 5.2 for a description of LPHSW.

4.2 Weld Overlay

Design and apply a weld overlay over the defective weld. The overlay will be a Type I overlay designed to restore the full structural integrity of the weld area without taking credit for the remaining uncracked ligament of the pipe.

See Appendix B for a description of the weld overlay process.

4.3 System Piping Replacement

Depending upon the extent and severity of detected cracking, complete system piping replacement will be considered.

5.0 MITIGATING ACTIONS

This section describes the options for mitigating actions which may be implemented to minimize the occurrence of IGSCC in uncracked welds.

5.1 Induction Heating Stress Improvement (IHSI)

If IHSI is implemented, GPUN will evaluate the following to establish the welds to be treated:

1) Damage Index Calculations to end-of-life show a propensity for developing IGSCC,
2) The weld has been repaired. Repair determination will be made by reviewing available weld documentation and/or visual inspection of the weld, or
3) Field experience at other similar plants.

Each weld to be IHSI'd will be ultrasonically inspected both before and after the treatment to ensure that no crack-like indications exist in the weld joints.

See Appendix C for a description of IHSI.

5.2 Hydrogen Water Chemistry

Another mitigating action being evaluated by the utilities, EPRI and the NRC is hydrogen water chemistry control. Hydrogen is added to the reactor feedwater system. The hydrogen promotes the radiolytic recombination of hydrogen and oxygen thereby reducing the dissolved oxygen concentration. In this reducing environment (low electrochemical potential), the susceptibility to IGSCC is significantly reduced, perhaps eliminated.

Hydrogen water chemistry control is currently in the developmental stage. Two BWR's, Dresden 2 and Ringhals 1 (Sweden) are being used as demonstration plants to obtain operational data. Earlier testing at Oskarshamn II has been completed.

GPUN considers that there will be insufficient data available to support full implementation during the 1986 outage. But we are investigating engineering modifications to allow limited testing of hydrogen water chemistry following the 1986 outage. Full implementation in the future will be based on research results and industry experience.

6.0 LEAK DETECTION AND LEAKAGE LIMITS

6.1 Leak Detection Systems

All identified leakage originating from inside the drywell, such as from pump seals and valve packing, is routed to the Drywell Equipment Drain Tank. Unidentified leakage, such as from pipe cracks, flows to the drywell floor drain sump. Liquid flows by gravity to the sump. Steam will be condensed by the drywell air coolers, and the condensate is routed to the sump [7].

There are three quantitative means of measuring the unidentified leak rate from inside the drywell.

1. There are two drywell sump pumps. One pump will activate upon the tripping of the upper level switch in the sump. When the water level in the sump passes the lower level switch, the pump is turned off. At this time, an automatic timer starts. The timer is set such that if the upper level switch is tripped before the timer runs out, an alarm sounds in the control room indicating an unidentified leak rate in excess of 4 gpm. The volume of water between the two level switches is approximately 80.5 gallons; the timer setting is approximately 20.5 minutes.

2. The total flow from the sump is measured by flow meters. Every 4 hours, or less, the readout of the meters is compared to the previous reading and the difference is divided by the time interval between readings.

3. There is a level indicator in the sump. The signal from this indicator is fed to a processor in the control room which continuously displays an "instantaneous" fill rate of the sump.

There are also qualitative means available to assist in leak detection. The temperature, pressure and humidity of the drywell are continuously monitored. Any increase in these indicators will be investigated to determine the cause. This may involve shutting down the plant and entering the drywell for inspection.

6.2 Leakage Limits

When the period between sequential operations of the floor drain sump indicates a leakage rate exceeding 4 gpm, an alarm sounds in the control room. The operator will take appropriate steps to attempt to identify the source of the leakage. This may involve shutting down the plant and entering the drywell for inspection. In any case, if the unidentified leakage rate exceeds 5 gpm, the plant will be shut down [8].

A Technical Specification revision is currently in preparation to add the requirement that if there is more than a 2 gpm increase in unidentified leakage in any 24 hour period during steady-state power operation, the plant will be shut down.

The total leakage in the containment, both identified and unidentified, may not exceed 25 gpm.

7.0 REFERENCES

1. "Inspections of BWR Stainless Steel Piping (Generic Letter 84-11)," USNRC, April, 19, 1984.
2. "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping, "NUREG-0313 Rev. 1, USNRC, July 1980.
3. "Isolation Condenser System Piping Cracked Welds - Repair and Failure Analysis", TDR 580, GPUN, August 1984.
4. "IGSCC Damage Index: Application of the IGSCC Damage Model to BWR Piping and Components", EPRI NP-2807-LD, EPRI, January 1983.
5. "Development of an Engineering Model for Predicting IGSCC Damage - Particularly in Type-304 Stainless Steel in BWR Water Environments," NP-2808-LD, EPRI, February 1983.
6. IE Bulletin NO. 83-02: "Stress Corrosion Cracking in Large - Diameter Stainless Steel Recirculation System Piping at BWR Plants", USNRC, March 4, 1983.

7. Oyster Creek FDSAR Amendment 32, Question 15.

8. Oyster Creek Technical Specification 3.3.D.

8.0 TABLES

I. Systems to be inspected.

Table I

Systems to be Inspected

System	Pipe Size (In)	Approximate # of Welds I(1)	O(2)	Extent
Recirculation	26	79	0	Vessel Inlets to Vessel Outlets -5 Loops
Reactor Water Cleanup	6	42	0	Between Recirculation Loop and valves V-16-2 and 14 (discharge) and V-16-61 (return).
Shutdown Cooling	14	9	0	From Recirculation Loop to dissimilar metal welds (discharge and return).
Core Spray	8	64	0	From Reactor Vessel to Valves V-20-21 and 41 (South) and V-20-15 and 40 (North)
Isolation Condenser System (3)	8	0	51 (7)*	Entire system inside and outside drywell.
	10	47	12 (1)*	
	12	0	54 (9)*	
	16	0	12 (1)*	

Notes: 1) I - Inboard of the second isolation valve.
2) O - Outboard of the second isolation valve.
3) The number in "( )" is the number of joints with weld overlays.

*Reference - NRC Isolation Condenser S.E.R.

9.0 APPENDICES

A. Damage Index Calculations

B. Weld Overlays

C. Induction Heating Stress Improvement [IHSI].

Appendix A

Damage Index Calculations

Damage Index calculations are performed to estimate whether or not a weld is susceptible to the development of IGSCC. The supporting data, including comparison of calculation results with actual cracking incidents at Dresden 2, are provided in EPRI reports NP-2807-LD (January 1983) and NP-2808-LD (February 1983).

The Damage Index calculations assess material (degree of sensitization, material properties), environmental (oxygen content of the water) and plant operational (stresses due startups, holds; cyclic history, and time) parameters in establishing the Damage Index.

The results of the calculations are then used to determine if IGSCC is likely or unlikely to occur.

Note that the terms "likely" and "unlikely" mean that there is a possibility that IGSCC may or may not occur. The results of Damage Index calculations cannot be taken as guarantees of whether or not a crack will develop.

Appendix B

Weld Overlays

The weld overlay is a repair method which results in a continuous band of weld material deposited on the pipe surface directly over the crack. There are three types of overlay designs:

1. Type I - The overlay is designed without taking credit for the uncracked ligament of the pipe. The designer assumes a 360° through-wall crack. Thusly, the overlay is designed to meet the Code requirements for structural integrity. Uncertainties in accurate sizing of cracks do not affect the design of the overlay.

2. Type II - The overlay is designed assuming a through-wall crack of a length equal to UT-measured length. This type of overlay is thinner than Type I since it does take credit for the uncracked pipe ligament.

   This type of overlay is normally used on cracks shorter than one-half the pipe circumference.

3. Type III - This type of overlay is used on shallow and short cracks. Credit is taken for the uncracked ligament of the pipe in both the radial and circumferential directions.

The overlay process typically develops compressive residual stresses within the inner portion of the pipe wall. These stresses will stop or retard crack growth. While this is an important factor in the design of Type II or III overlays, it is irrelevant to the design of Type I overlays.

GPUN will use Type I overlays to provide structural integrity. Thusly, the accuracy of crack measurements does not enter into the design of the overlays. And, the development of compressive residual stresses is not technically necessary.

Weld overlays are currently considered to be a short-term repair. Generally, piping replacement, whether limited or complete, occurs during the scheduled outage following repair. However, research on the justification of continued service of overlays beyond one cycle is progressing.

The weld overlay process has been applied on nearly 300 weld joints in nuclear power plants. Two plants are currently requesting approval to continue operation without replacing overlayed joints.

Appendix C

Induction Heating Stress Improvement (IHSI)

IHSI is a treatment used on uncracked welds to change the stresses at the inner portion of the pipe wall from tensile to compressive. By eliminating tensile stresses, one prevents IGSCC because, without tensile stress, IGSCC cannot occur.

IHSI is implemented by placing an induction heating coil around the weld to be treated. Cooling water is flowed through the pipe. The heat from the coil yields the outer surface in compression while the cool inside surface yields in tension. After cooldown, the stresses reverse, leaving the OD in tension and the ID in compression. The induction coil, heat input, water flow and other operating parameters are designed for each joint being treated.

Research to date has shown that IHSI is an effective means of mitigating IGSCC. The NRC has accepted IHSI treatments and many utilities have implemented, committed to , or plan IHSI treatments in their plants. A partial listing of those plants is shown below

- Dresden 3
- Quad Cities 1 and 2
- Peachbottom 2
- Millstone
- Susequehanna 1
- Duane Arnold
- Monticello
- Hatch 2
- Browns Ferry 2 and 3
- Zimmer
- Hanford 2
- Vermont Yankee