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U. S. Nuclear Regulatory Commission
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Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

Subject: Core Shroud Inspection Results

References: (1) Generic Letter (GL) 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors"
(2) Letter from M. Pacilio (AmerGen Energy Company, LLC) to U. S. NRC, "Core Shroud Inspection Plan," dated December 29, 2001

In Reference 1, the U. S. Nuclear Regulatory Commission (NRC) requested that each boiling water reactor inspect their core shroud and perform an appropriate evaluation and/or repair based on the results of the inspection.

In Reference 2, AmerGen Energy Company (AmerGen), LLC committed to complete the core shroud inspection at Clinton Power Station (CPS) during the Spring 2002 refueling outage (C1R08). Attachment 1 to this letter provides the results of the core shroud inspection in accordance with the request in Reference 1. The results include the details of scope, inspection techniques, inspection results and summary of the evaluation to support operation through at least the next scheduled refueling outage (C1R09), currently scheduled for January 2004.

AmerGen used the inspection methods, scope and flaw evaluation criteria contained in the guidelines of Boiling Water Reactor Vessel and Internals Project (BWRVIP) 76, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines." While the NRC has not issued the final Safety Evaluation Report for BWRVIP-76, AmerGen has committed to the guidelines contained within BWRVIP-76. Representatives from AmerGen, Exelon Generation Company, General Electric Company and the NRC participated in a telephone conference on April 24, 2002, to provide preliminary results of the core shroud inspection. This letter provides the formal results of the inspection as requested by Reference 1.

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Should you have any questions related to this information, please contact Mr. Jim L. Peterson at (217) 937-2810.

Respectfully,

Keith J Polson 06/06/02

K. J. Polson
Plant Manager
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Attachment: Clinton Power Station Core Shroud Inspection Results

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Clinton Power Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

Core Shroud Scanning and Inspection Results

As required by NRC Generic Letter 94-03 (Reference 1), BWRVIP-01 (Reference 2), and BWRVIP-76 (Reference 3), AmerGen Energy Company (AmerGen) LLC planned to inspect the reactor core shroud at Clinton Power Station (CPS) during the eighth refueling outage (C1R08) as a Category 'B' shroud. This plan consisted of inspecting horizontal welds H3, H4, H6a, H7 by ultrasonic testing (UT) methods. As a contingency plan, AmerGen had prepared to expand the inspection scope to category 'C' requirements should cracking be observed in greater than 10% of the total weld length for any inspected weld. In support of this inspection, AmerGen had completed fluence profile calculations for welds in the belt line region. Also completed was the BWRVIP-76, Appendix 'D' analysis for welds H6a, H6b, and H7 since the inspection accessibility of these welds were known to be less than 50%.

Significant cracking was identified in the H4 weld which resulted in re-categorizing the shroud to category 'C'. This re-categorization expanded the scope to include horizontal welds H1, H2, H5, and H6b as well as vertical welds V11, V12, V13, and V14, which intersect with weld H4. Cracking was also identified in welds H3, H5, and H6b. A plant-specific evaluation was performed for the H3, H4, and H5 horizontal welds. The cracking observed in weld H6b was less than 10% of the examined length, therefore, no further evaluation was performed for weld H6b. Table 1 provides the details of the UT results.

Table 1

Weld Number	Total Weld Length(inches)	Weld Length Examined (inches)	Weld Length Flawed (inches)	Percent of Examined Weld Length Flawed
H1	611.42	365.10	0	0
H2	611.42	411.79	0	0
H3	584.34	389.54	70.28	18.0
H4(upper side)	584.34	584.34	567.98	97.2
H4(lower side)	584.34	567.57	419.75	74.0
H5(upper side)	584.34	111.20	16.96	15.3
H5 (lower side)	584.34	109.42	0	0
H6a	584.34	95.72	0	0
H6b	565.36	144.67	7.7	5.4
H7	565.36	149.87	0	0
V11	82.17	78.23	0	0
V12	82.17	78.07	0	0
V13	74.29	64.61	0	0
V14	74.29	64.61	0	0

It can be seen that there was no cracking identified in horizontal welds H1, H2, H6a, and H7 welds and vertical welds V11, V12, V13, and V14. Cracking identified in weld H6b is less than 10% of the examined weld length, therefore no further analysis is required. In accordance with BWRVIP-76, the cracking in welds H3, H4, and H5 required plant-specific analysis. General Electric (GE) has performed this required analysis for CPS. The following sections summarize this analysis.

Structural Evaluation of Core Shroud at Clinton Power Station

The cracking was evaluated per GE's structural shroud evaluation (Reference 4), and the CPS core shroud was found acceptable for continued plant operation for at least one operating cycle. The technical evaluations considered the effects of extended power uprate (EPU) and GE14 fuel. This evaluation assumed normal water chemistry (NWC) and a crack growth rate of 5.0×10^{-5} inches/hour (in/hr).

Assumptions/Approaches

A number of assumptions and approaches were used in the structural assessment of welds H3, H4, and H5. These are described below.

(1) The fluence for the H4 weld was projected. For the purpose of this analysis, the metal between azimuths where the projected fluence exceed 3×10^{20} neutrons per square centimeter (n/cm^2) at the end of the current cycle was removed.

(2) The projected fluence levels at the H3 and H5 welds were determined to be well below 3×10^{20} n/cm^2 at the end of the current cycle.

(3) The crack growth rate used in the length and depth directions were 5×10^{-5} in/hr and 2.2×10^{-5} in/hr, respectively, in accordance with BWRVIP-76. Only the length direction crack growth is used for areas where through-wall cracking is assumed. This calculation assumed NWC conditions for Cycle 9 operation.

(4) Based on a conservative 21-month duration of operation for Cycle 9 and 90% availability factor, 14060 hours of hot operations were assumed.

(5) The UT inspections were conducted using the procedures outlined in demonstration number 19 of BWRVIP-03 (Reference 5). The UT uncertainty in the depth direction was taken as 0.07 in. For flaws in the outside diameter (OD), the length uncertainty was assumed as 0.199 in, which corresponds to a 45-degree shear wave case. This value was added at each end of the flaw. For inside diameter (ID) flaws, the length uncertainty was assumed as 0.331 in, which corresponds to a 60-degree longitudinal wave case. For flaws whose length were determined through more than one setting, a placement uncertainty of 0.5 degrees was added at each of the flaw.

Evaluation Summary

Welds H3, H4, and H5 showed flaws that require plant specific analysis in accordance with Reference 3. GE's evaluation (Reference 4) demonstrated that with the existing flaws in welds H3, H4, and H5, the shroud is qualified to the BWRVIP-76 guidance for at least one operating cycle (end of Cycle 9) assuming normal water chemistry.

The following loads are considered in this analysis:

- Dead weight
- Differential Pressure loads
- Seismic loads (OBE, SSE)
- Safety Relief Valve Discharge Hydrodynamic loads (SRV,SRV-ADS)
- Annulus Pressurization and Jet Reaction loads
- Vent Clearing loads
- Acoustic load (AC) and Flow Induced load (FIL)
- Fuel Lift loads
- Chugging loads

The Safety Factors calculated for Welds H3, H4, and H5 are reported in Table 2.

Table2

Weld Number	Governing Operating Condition	Required Safety Factor	Calculated Safety Factor
H3	Faulted	1.39	52.63
H4	Faulted	1.39	6.98
H5	Faulted	1.39	3.95

The calculated safety factor values identified above exceed the required values. As a result, it is concluded that the required safety margins for welds H3, H4, and H5 are maintained to the end of Cycle 9.

Evaluation of H3 Weld

The average crack depths at OD and ID were calculated using the guidance provided in BWRVIP-76, Appendix I. Bounding average crack depths on the ID and OD were used in the structural evaluation. Since the fluence at this weld is calculated to be less than $3x10^{20}$ at the end of Cycle 9, only a limit load evaluation using the computer program Distributed Ligament Length (DLL) was conducted. The details of the structural margin calculation are included in the Reference 4 evaluation.

Evaluation of H4 Weld

The inspection coverage for this weld was 100%. The average crack depths at OD and ID were calculated using the guidance provided in BWRVIP-76, Appendix I. Bounding average crack depths on the ID and OD were used in the structural evaluation. In accordance with the guidance provided in BWRVIP-76, Appendix D (Paragraph D.1.1), through-wall crack depth was assumed in regions where the calculated fluence exceeded $3x10^{20}$ n/cm^2 at the end of Cycle 9. This obviates the need for linear elastic fracture mechanics evaluation. Therefore, only the limit load evaluation was conducted using the computer program DLL. The details of the structural margin calculation are included in Reference 4.

Evaluation of H5 Weld

Due to access restrictions, the UT inspection at this weld consisted of finding 'unflawed metal' through accessible areas centered on the 0 degree and 180 degree core shroud azimuths. Since the fluence at this weld is calculated to be less than $3x10^{20}$ n/cm^2 at the end of Cycle 9, only limit load evaluation using the computer program DLL was conducted. Guidelines provided in BWRVIP-76, Appendix D were followed. The details of the structural margin calculation are included in Reference 4.

Summary of Evaluation Results

The calculated values of structural safety factors at the H3, H4 and H5 welds for the limiting operating condition are summarized in Table 2. A comparison with the required values indicates that all of the calculated safety factor values exceed the required values. Therefore, it is concluded that the required safety margins at welds H3, H4 and H5 are maintained for the duration of Cycle 9. Since the structural evaluation did not predict any through-wall crack growth, no explicit leak rate calculations were conducted.

Plans for Noble Metal Chemical Addition and Hydrogen Addition

CPS performed noble metal chemical addition at the beginning of C1R08. CPS is planning to install a hydrogen addition modification early in Cycle 9. After the installation of the hydrogen addition modification, CPS plans to re-evaluate the core shroud welds. CPS is expecting to qualify the shroud welds for at least 2 operating cycles.

Conclusions

The inspection and evaluation of the CPS core shroud was completed during C1R08 in accordance with the BWRVIP-76 guidelines. All welds were evaluated as acceptable for at least the current cycle of operation (i.e., Cycle 9). No exceptions to the BWRVIP-76 guidance were needed.

The results of the inspections demonstrated sufficient structural integrity of the core shroud for continued operation for at least one cycle. During C1R08, noble metal chemical addition was applied to the reactor coolant system. AmerGen is planning to install a hydrogen addition modification early in the current operating cycle. No credit was taken for these intergranular stress corrosion cracking mitigation options in determining the crack growth rates used in the evaluations.

References

(1) NRC Generic Letter 94-03, "Intergranular Stress Corrosion Cracking (IGSCC) of Core Shrouds in Boiling Water Reactors"

(2) BWRVIP-01, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines," October 1996

(3) BWRVIP-76, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines," December 1999

(4) GE Report GENE-0000-0003-9600-1, Rev. 0, "Structural Evaluation of Core Shroud Welds," April 2002

(5) BWRVIP-03, "BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines," Revision 3, December 2000.