UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

50-220

November 13, 1998

LICENSEE: Niagara Mohawk Power Corporation

FACILITY: Nine Mile Point Nuclear Station, Unit No. 1

SUBJECT: SUMMARY OF MEETINGS WITH LICENSEE AND PUBLIC ON SEPTEMBER 24, 1998, REGARDING CORE SHROUD REINSPECTION SCHEDULE (TAC NO. M99720)

On September 24, 1998, the NRC staff participated in a meeting with Niagara Mohawk Power Corporation (NMPC and licensee) regarding a proposed extension to the schedule for reinspecting the vertical welds in the core shroud at Nine Mile Point Nuclear Station, Unit No. 1 (NMP1). The meeting, held from 5:00 to 7:00 p.m., was followed by an NRC meeting with the public from 7:30 p.m to 12:15 a.m. on the same subject. The meetings were held in Snygg Hall at State University of New York in Oswego, New York.

The agenda and a partial list of NRC attendees are given in Enclosure 1. NMPC participants included Messrs. J. Mueller, R. Abbott, C. Terry, R. Smith, and G. Inch. Contractor personnel for NMPC included Dr. M. Manahan, Sr. of MPM Technologies; Dr. S. Ranganath and R. Horn of General Electric Nuclear Energy; and Messrs. R. Smith, A. Gianuzzi, and R. Matson of Structural Integrity, Inc. Both meetings were well attended by state and local officials, members of the public, various organizations, and local news media.

The purpose of the meeting with NMPC was to review the technical basis for NMPC's request in a letter dated February 27, 1998, and several supplemental submittals, that the NRC consent to extending the schedule for reinspecting the vertical welds in the NMP1 core shroud. In the February 28, 1998, letter, NMPC concluded that NMP1 can be safely operated with the current operating cycle extended beyond that which NMPC had previously proposed and which the NRC had accepted. Specifically, NMPC provided a revised crack growth rate basis and a structural margin analysis for extending the 10,600 hot operating hours that the NRC staff approved in a letter dated May 8, 1997, to 14,500 hours.

In its letters and during the meeting, NMPC reviewed the basis for the 10,600 hours interval and developments since NMP1 restart in May 1997. These developments include the NRC's issuance of a safety evaluation on a slower crack growth rate (2.2×10^{-5} in/hr) based on Boiling Water Reactor Vessel and Internals Project (BWRVIP) report, BWRVIP-14, "Evaluation of Crack Growth in BWR Stainless Steel Reactor Pressure Vessel Internals," NRC approval of the NMPC finite element fracture mechanics and limit load analysis of the vertical welds, and the safety assessment of the vertical weld cracking. NMPC discussed metallurgical evaluations of the two vertical weld boat samples and additional structural margin analyses that have been completed. NMPC showed that, even at the higher crack growth rate (5×10^{-5} in/hr), its supplemental fracture mechanics analysis (performed with BWRVIP-01 guidelines and with credit for uncracked locations) demonstrates that structural margins required by the American Society of Mechanical Engineers Boiler and Pressure Vessel Code are maintained for more than the 14,500 hours of operation. NMPC reviewed NMP1's conformance with each of the conditions in the NRC's safety evaluation for BWRVIP-14, including NMP1's coolant chemistry which has been maintained below the Electrical Power Research Institute's guidelines, and neutron fluence which at the remaining ligaments of the vertical welds would remain within the limit of 5×10^{20} n/cm^2

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once the 14,500 hours of operation was reached. Details of NMPC's presentations are given in their submittals to the NRC staff dated September 30, 1997; January 30, February 27, March 31, April 16 and 30, June 30, and September 21, 1998; and are not repeated here. Enclosure 2 presents the viewgraph slides and handouts used by NMPC and its contractors.

The meeting with the public included introductions of local officials and members of various organizations by Ms. Barbara Brown, Legislator of Oswego County. Numerous questions and expressions of concern for shroud integrity were received and discussed by the NRC staff. The public comments expressed a clear preference that the reinspection be performed once the 10,600 hours has been reached and a desire for the strongest possible oversight of nuclear reactors by the NRC. The public's preference was based upon the higher assurance afforded by actual observation compared to reliance upon calculations. One member of the public requested that the NRC determine the maximum allowable deterioration of the shroud and its minimum margins before acting upon NMPC's request; Mr. Hermann of the NRC explained that degraded components are inspected and evaluated at predetermined intervals during service life in order to assure that Code required margins will be met during that pre-analysized period of operation. Another member of the public stated that a petition opposing the extension request and containing over 300 signatures would soon be sent to the NRC. Ms. Kavanagh and Mr. Caruso of the NRC answered several questions about shroud leakage potential and consequences. One member of the public was concerned that crack growth would accelerate once leaking commenced due to the effects of chemistry; Dr. Shack (an NRC contractor) responded that experiments have demonstrated that leakage actually slows crack growth rate by diluting or flushing away the chemical deposits within the crack. Mr. Bajwa responded to questions regarding the NRC's decision process and policies. Messrs. Doerflein and Norris of NRC Region I addressed certain prior events at the NMP facilities (not related to the shroud) for which some members of the public expressed concern. Mr. Lois of the NRC replied to questions regarding the relationship between neutron fluence and intergranular stress corrosion cracking and how the fluence at the NMP1 shroud was measured and calculated. Asked about the NRC's schedule, Mr. Hood of the NRC stated that the current target date for reaching a decision is November 1, 1998. Several people expressed appreciation for the meeting and requested that more meetings on issues of local concern be held in the future. The NRC staff noted that comments received during the meeting would be considered during the staff's continuing review of the extension request.

Sincerely,

J Cushing for D Hood

Darl S. Hood, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-220

Enclosures: 1. Agenda and NRC attendees
2. NMPC and contractor slides

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AGENDA

September 24, 1998
Meeting Regarding Inspection of Core Shroud Vertical Welds at
Nine Mile Point Nuclear Station Unit 1

I. NRC SESSION WITH NIAGARA MOHAWK POWER CORPORATION (NMPC)

5:00	NRC Opening Remarks	Darl Hood
	Purpose Introduction of Participants	
5:05	Background	Robert Hermann
5:10	NMPC's Review of Request to Extend Core Shroud Inspection Interval	Richard Abbott et al.
	Introduction Core Shroud Boat Sample Tests and Evaluations Application of BWRVIP-14 to Unit 1 Core Shroud Weld Cracks Conclusions	
6:30	NRC Questions/Comments	
7:00	Break	

II. NRC SESSION WITH PUBLIC

7:30	NRC Opening Statements	Darl Hood
7:35	Questions/Comments from Audience	
9:30	NRC Closing Remarks	Singh Bajwa

Enclosure 1

NRC ATTENDEES

Office of Nuclear Reactor Regulation, Rockville, MD:

Singh S. Bajwa	Director Project Directorate I-1
Darl S. Hood	Senior Project Manager Project Directorate I-1
Robert A. Hermann	Senior Level Advisor-Materials Science Materials and Chemical Engineering Branch Division of Engineering
William H. Koo	Senior Materials Engineer Materials and Chemical Engineering Branch Division of Engineering
Ralph Caruso	Section Chief Reactor Systems Branch Division of Systems Safety and Analysis
Kerri A. Kavanagh	Reactor Systems Engineer Reactor Systems Branch Division of Systems Safety and Analysis
Dr. Lambros Lois	Senior Reactor Systems Engineer Reactor Systems Branch Division of Engineering

Region I, King of Prussia, PA:

Lawrence T. Doerflein	Chief, Project Branch 1 Division of Reactor Projects
Barry S. Norris	Senior Resident Inspector Nine Mile Point Nuclear Station
Neil A. Sheehan	Senior Public Affairs Officer Public Affairs Staff

NRC Contractor:

Dr. William J. Shack	Associate Division Director of the Energy Technology Division Argonne National Laboratory

NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT NUCLEAR STATION UNIT 1

NRC/NMPC
Nine Mile Point Unit 1
Core Shroud Meeting

September 24, 1998

Agenda

Opening Remarks	J. H. Mueller
Introductions	R. B. Abbott
Purpose	R. B. Abbott
Background	C. D. Terry
Results of Evaluation	G. Inch
	R. Horn
	M. Manahan
Results of Structural Margin Assessment	G. Inch
Conclusion	R. B. Abbott

Meeting Purpose

- Present supplemental information applied as basis for extending shroud reinspection
  - NMP1 shroud metallurgical, fluence, and crack growth assessment submitted February, 1998
  - NMP1 supplemental shroud structural margin analysis submitted April, 1998
  - Neutron transport analysis - September, 1998
- Applicability of BWRVIP-14

Background

- The BWRVIP developed industry standardized shroud inspection, evaluation and repair criteria which were approved by the NRC
- Unit 1 shroud horizontal welds preemptively repaired in 1995
- All vertical welds inspected in 1997 consistent with BWRVIP criteria for repaired shrouds
- Cracks were observed and boat samples removed for metallurgical evaluation

Background

- April 1997, NMPC provided justification, consistent with BWRVIP-01 guidelines, for 10,600 hours of hot operation
- May 8, 1997, NRC issued an SER allowing operation for 10,600 hours prior to reinspection of the vertical welds
- February 27, 1998, the NMPC submittal requested to extend operation from 10,600 hours to 14,500 hours, based upon metallurgical evaluation and reassessment of crack growth rates for welds V9 and V10
- April 30, 1998, NMPC submitted results of supplemental structural margin assessment of welds V4, V9 and V10, consistent with BWRVIP-01 guidance, to further support operation for 14,500 hours
- On June 8, 1998, the NRC issued an SER on BWRVIP-14 which is directly applicable to the NMP1 cracking

Basis of the Vertical Weld 10,600 Hour Inspection Interval

- 100% inspection of all accessible vertical and horizontal welds consistent with BWRVIP-01 and BWRVIP-07
- Finite element Linear Elastic Fracture Mechanics (LEFM) analysis of V9 and V10 part through wall cracks based on fracture toughness of (150 ksi $\sqrt{in}$) consistent with BWRVIP-01 evaluation guidelines
- Limit Load Analysis for V4, V15, and V16
- Operating interval was defined based on CGR of 5.0×10^{-5} in/hr
- No credit for horizontal weld integrity
- Part through wall cracking assumed at locations where UT identified uncracked ligament
- Operate within EPRI water chemistry guidelines
- Complete boat sample evaluations

Actions Since April 1997 Inspection and Evaluation

- NRC approved the NMPC finite element fracture mechanics and limit load analysis of the vertical welds and the safety assessment of the vertical weld cracking
- NMPC has operated well below the EPRI water chemistry guideline commitment (conductivity <.3 μS/cm, sulfate <5 ppb, chloride <5ppb)
  - avg. conductivity 0.076 μS/cm
  - avg. sulfate 2.01 ppb, avg. chloride <0.5 ppb
- NMPC completed detailed metallurgical evaluations of the vertical weld boat samples
- Additional structural margin analysis completed
- The NRC issued BWRVIP-14 SER which supports lower CGR

Basis of the Vertical Weld 14,500 Hour Inspection Interval

- Metallurgical and fluence evaluations justify 14,500 hours based upon lower CGR:
  - PLEDGE analysis CGR confirms 2.2×10^{-5} in/hr with significant margin
  - Cracking confirmed as IGSCC, consistent with basis of BWRVIP-14
  - Analysis satisfies the BWRVIP-14 SER conditions
    - Fluence will remain below 5×10^{20} n/cm^2
- Supplemental structural analysis which satisfies BWRVIP-01 analysis guidelines justifies greater than 14,500 hours at the assumed 5×10^{-5} in/hr CGR

Vertical Weld Boat Sample Evaluations

- Two boat samples removed
- Boat samples exhibit expected IGSCC characteristics
  - Crack located in heat affected zone (HAZ)
  - Surface cold work
  - No extensive crack tip branching, grain encirclement or grain dropout characteristic of irradiation effects
- Results confirm UT sizing (within .1 inch)
- Results confirm excellent material ductility
- Tensile properties are consistent with irradiation of material in the 3×10^{20} n/cm^2 range
- Boat sample based fluence measurements, confirm that analysis predictions of vertical weld peak fluence are conservative
- Metallography and other measurements confirm assessment of material sensitization
- Conclusion: Vertical weld is IGSCC which is typical of BWR core shroud cracking with no observed evidence of irradiation effects

NRC SER Crack Growth Assessment

- NRC SER issued June 8, 1998 on the BWRVIP-14 crack growth rate concludes that the three approaches are acceptable subject to staff review and the following conditions:
  - Fabrication weld repairs, etc., are considered in evaluating the residual stress
    - Fabrication records show no repairs to vertical weld
    - NMP1 analysis reviewed fabrication practices (MPM-497439)
  - Components are operated in accordance with EPRI BWR water chemistry guidelines
    - NRC approved NMP1 Technical Specification which incorporates EPRI guidelines
  - Crack tip stress intensity is explicitly less than 25 ksi $\sqrt{in}$ where applicable in structural analysis
    - NMP1 analysis shows stress intensity will remain less than 25 ksi $\sqrt{in}$(GE-NE-B13-01869-113, GE-NE-523-B13-01869-043)
  - Fluence less than 5×10^{20} n/cm^2
    - MPM-009476

NMPC Crack Growth Assessment Summary

- Evaluations based on both GE PLEDGE model and the BWRVIP-14 correlation
- Evaluations consider all the factors which affect potential crack growth rate
  - Vertical weld residual and fabrication stresses (BWRVIP-14, NMP1 analysis)
  - NMP1 operating chemistry (Plant Data)
  - Corrosion potential (NMP1 data and BWR data)
  - Material fluence (Analysis and Boat sample)
  - Material sensitization (Boat sample data, GE data, BWRVIP-14)
- Conclusions:
  - PLEDGE predicts CGR at or below 0.42×10^{-5} in/hr
  - Use of 2.2×10^{-5} in/hr bounds predicted CGR (factor of 5)
  - Application of 2.2×10^{-5} in/hr supports a cycle greater than 24 months
  - Substantial margin exists

Role of Irradiation Effects on NMP1 Shroud

- GE presentation (Dr. R. Horn)

Effects of Irradiation on Shroud Cracking

- High fluence can contribute to the susceptibility of the material
  - Can produce chromium depletion at grain boundaries
  - Sensitization can be found outside of the weld HAZ
- Cracking will exhibit additional features:
  - Significant grain fallout
  - Significant crack branching in higher fluence regions
- Irradiation will also produce significant hardening of the base material

Comparison of Boat Sample Data

Key Factors	Comparison Plant	NMP1
Fluence	8×10^{20}	$<3 \times 10^{20}$
Cracking in Non-sensitized Material	Yes	No
Significant Grain Fallout	Yes	No
Crack Branching	Yes	No
Significant Hardening	Yes	No

Summary

- The NMP1 shroud boat samples allowed a comparison with the earlier evaluation, performed on a boat sample from another shroud, irradiated to higher fluence
  - Locations of sensitization
  - Cracking morphology
  - Base material characteristics
- Unit 1 crack evaluation indicates no irradiation effects
  - Limited levels of base material hardening
  - No significant grain fallout
  - No significant crack branching
  - Cracking correlated with regions of weld induced sensitization
  - Fluence was below levels where irradiation effects are important

NMP1 Shroud Neutron Transport Analysis

- MPM Technologies, Inc. Presentation (Dr. M.P. Manahan, Sr.)

Analysis of Boat Sample Dosimetry Data

- Two boat samples were cut from the shroud at the end of cycle 12
  - ID surface of V9 26.4 inches above midplane (peak ID measured fluence = 3.49×10^{20}n/cm2)
  - OD surface of V10 8.3 inches below midplane (peak OD measured fluence = 1.42×10^{20}n/cm2)
- Dosimetry data taken at three depths within each boat sample

Analysis of Boat Sample Dosimetry Data (continued)

- Analysis by Framatome in January, 1998 using cycle 7 transport data showed a discrepancy between the Fe and Ni dosimeters
- Analysis of the 210 degree surveillance capsule dosimetry in May,1998 by MPM using a mid-cycle 12 transport analysis showed a similar discrepancy
- In May, 1998 MPM suggested that a large flux drop through cycle 12 would explain the discrepancy

Boat Sample Analysis Results

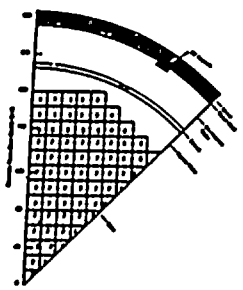
- Through cycle analysis has resulted in close agreement between Fe and Ni dosimeters
- Average ratio of the fluxes from Ni to those from Fe are 0.991 with a standard deviation of 3.3%
- Calculations at the boat sample locations have been shown to be conservative by comparison with the measured fluxes

Neutron Flux Calculations

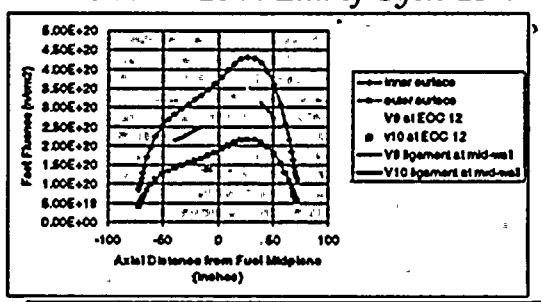
Analyses Include:

- R-θ, R-Z, and R calculations for 5 cycle 12 representative power profiles (15 transport calculations)
- Uncertainty Analysis

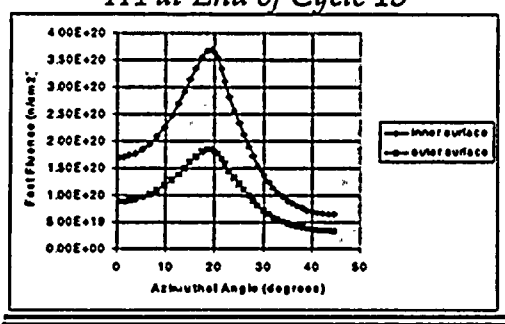
NMP-1 R-θ Geometry



Calculated Fast Fluence to Welds V9 and V10 at End of Cycle 13



Calculated Fast Fluence to Weld H4 at End of Cycle 13



Neutron Transport Results for Shroud Welds

Weld Identification	Location			Cycle 12 Fast (E > 1) Fluence (n/cm²)	Cycle 13* Fast (E > 1) Fluence (n/cm²)
	ID Surface Radius (in)	Height Above Midplane (in)	Angle (degrees)		
H1	93	102.18	19.38	1.2e+19	1.4e+19
H2	93	70.93	19.38	7.2e+19	7.9e+19
H3	88	48.93	19.38	1.4e+20	1.5e+20
H4	88	30.43	19.38	3.4e+20	3.7e+20
H5	88	-39.69	19.38	2.6e+20	2.9e+20
H6A	88	-103.19	19.38	5.3e+18	6.1e+18
H6B	88	-107.69	19.38	3.3e+18	3.7e+18
H7	88	-129.82	19.38	2.7e+17	2.9e+17
V9/V10	88	27.00	20	3.9e+20	4.3e+20

* Calculations for cycle 13 are for 14,300 EFPH past the end of cycle 12

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Neutron Transport Results for V9/V10 at End of Cycle 13

[illegible]	[illegible]	Comment	[illegible]	[illegible]
V9	[illegible]	[illegible]	[illegible]	[illegible]
V9	[illegible]	[illegible]	[illegible]	[illegible]
V9	[illegible]	[illegible]	[illegible]	[illegible]
V10	[illegible]	[illegible]	[illegible]	[illegible]
V10	[illegible]	[illegible]	[illegible]	[illegible]
V10	[illegible]	[illegible]	[illegible]	[illegible]
V10	[illegible]	[illegible]	[illegible]	[illegible]
V10	[illegible]	[illegible]	[illegible]	[illegible]

Summary and Conclusions

- Through cycle transport calculations for cycle 12 have brought the Fe and Ni dosimeter measured fluxes into agreement
- The calculated fluences at the boat sample locations exceed the measured values by 16% indicating that the calculations at the shroud are conservative
- The peak fluence to the V9 and V10 remaining ligaments will not exceed $5.0 \times 10^{20} n/cm^2$ at 14,500 EFPH past the end of Cycle 12

Supplemental Structural Margin Analysis

- The follow-up supplemental fracture mechanics analysis, demonstrates that the required ASME code required margins are maintained, for more than 14,500 hours, even assuming a CGR of 5×10^{-5} in/hr
  - Analysis consistent with BWRVIP-01 guidelines
  - Credit taken for uncracked locations confirmed by both volumetric inspections (UT) and visual inspections (EVT-1) for V9 and V10
  - Credit taken for far side detection capability of UT as qualified by BWRVIP-03 for V4 weld
  - V4, V9 and V10 limit load evaluations show significant margin

Concluding Remarks

- There is substantial basis for reduced crack growth rate
- Fluence effects are not significant
- Structural analysis demonstrates inspection interval of 14,500 hrs is justified without reducing CGR

EVALUATED CRACK GEOMETRIES

ORIGINAL ANALYSIS

SUPPLEMENTAL ANALYSIS