October 30, 2000

Mr. John H. Mueller
Chief Nuclear Officer
Niagara Mohawk Power Corporation
Nine Mile Point Nuclear Station
Operations Building, Second Floor
P.O. Box 63
Lycoming, NY 13093

SUBJECT: NINE MILE POINT NUCLEAR STATION, UNIT NO. 2 - SAFETY EVALUATION OF CORE SHROUD INSPECTION RESULTS (TAC NO. MA9057)

Dear Mr. Mueller:

By letter dated April 28, 2000, and supplemented by letter dated October 23, 2000, Niagara Mohawk Power Corporation (NMPC) submitted its core shroud reexamination results and the associated flaw evaluation for the detected flaws. The ultrasonic (UT) reexamination of the core shroud was conducted during refueling outage (RF07). Only welds H4 and H5 were reinspected according to NMPC's reinspection plan. NMPC intended to demonstrate through an analytical flaw evaluation that the unit could be operated without repair of the H4 weld for one fuel cycle and for the H5 weld for three fuel cycles.

The NRC staff has completed the review and found that the flaw evaluation meets the intent of the rules in Section XI of the American Society of Mechanical Engineers (ASME) Code. Since the safety factors associated with the detected cracks are greater than 2.77 as specified in the ASME Code, the staff concludes that Nine Mile Point Unit No. 2 can be operated without repairing weld H4 for one fuel cycle and weld H5 for three fuel cycles. For details, see the enclosed safety evaluation. This completes the staff's efforts on NMPC's submittals.

Sincerely,

/RA/

Peter S. Tam, Senior Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-410

Enclosure: As stated

cc w/encl: See next page

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*Memo of 8/23/00
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CORE SHROUD REINSPECTION RESULTS FROM REFUELING OUTAGE (RF07)

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION, UNIT NO. 2

DOCKET NO. 50-410

1.0 INTRODUCTION

By letter dated April 28, 2000, and supplemented by letter of October 23, 2000, Niagara Mohawk Power Corporation (NMPC, the licensee) submitted the core shroud reexamination results and the associated flaw evaluation for the detected flaws for Nine Mile Point, Unit 2. The ultrasonic testing (UT) reexamination of the core shroud was conducted during refueling outage (RF07). Only welds H4 and H5 were reinspected according to NMPC's reinspection plan. NMPC intended to demonstrate through an analytical flaw evaluation that the unit could be operated without repairing weld H4 for one fuel cycle and weld H5 for three fuel cycles.

2.0 EVALUATION

2.1 NMPC's Analysis

NMPC used its distributed ligament length (DLL) flaw evaluation methodology (BWRVIP-20), to perform flaw evaluations for welds H4 and H5. The DLL methodology is capable of analyzing a core shroud weld with multiple flaws using either the limit load or the linear elastic fracture mechanics (LEFM) analysis. Since the predicted fluence at the end of cycle 8 for the H4 weld exceeds the LEFM threshold fluence of 3.0×10^{20} n/cm^2 as specified in the Topical Report BWRVIP-01, Revision 1 (dated March 1995, and also referred to as GENE-523-113-0894, Rev. 1, "BWR Core Shroud Inspection and Evaluation Guidelines"; approved by the staff on June 16, 1995), the licensee performed both LEFM and limit load evaluations for weld H4. For weld H5, however, only limit load evaluation was performed because the predicted fluence of 2.0×10^{20} n/cm^2 at the end of cycle 8 for this weld is below the threshold. The results from the limit load analysis indicated that the calculated safety factor is 8.58 for weld H4 and 5.11 for weld H5, exceeding the Code-required value of 2.77 by a large margin. These calculated safety factors used the normal and upset stresses because the normal and upset conditions were found to be limiting.

The LEFM methodology applied to weld H4 is the compound crack approach similar to that in the licensee's submittal dated July 9, 1998, for the evaluation of core shroud examination results from RF06. The methodology was based on a fracture mechanics model of multiple flaws with uniform depth. The results indicated that the calculated safety factor was 3.01 for a K_{Ic} value of 150 ksi(in)^{½}, exceeding the Code-required value of 2.77. For weld H4, both the limit

load and the LEFM analyses employed an initial crack depth of 0.58 inch, a UT uncertainty of 0.108 inch, and a crack growth of 0.80 inch in both depth and length directions which resulted from using the bounding growth rate of $5x10^{-5}$ inch/hour for 16,000 hours. For weld H5, the limit load analysis employed the same parameters except that a growth rate of $2.2x10^{-5}$ inch/hour, allowed by the Topical Report BWRVIP-14 for fluences smaller than $5.0x10^{20}$ n/cm^2, was used in the depth direction for 48,000 hours (3 cycles of operation) while the growth rate in the length direction remained $5x10^{-5}$ inch/hour for the same number of hours. Based on the results from the limit load and the LEFM analyses, the licensee concludes that welds H4 and H5 meet the structural margin requirements for continued operation after RF07 without repair for one fuel cycle and three fuel cycles, respectively.

2.2 NRC Staff's Evaluation

The licensee's flaw evaluation for the detected flaws on the horizontal welds of the core shroud was documented in BWRVIP-01, Rev. 1, supplemented by the submittal dated July 9, 1998, for flaw evaluations of core shroud examination results for RF06 and the current submittal for RF07. The licensee's evaluation employed limit-load and LEFM analyses. The staff determined the licensee's use of the limit load analysis for welds H4 and H5 and the LEFM analysis for weld H4 are appropriate because the methodologies were selected according to the guidelines (based on fluence levels) established in BWRVIP-01, Revision 1. Further, the staff determined that the limit load analysis for multiple flaws in a circumferential weld is an extension from the limit load analysis for a single flaw in a circumferential weld specified in Appendix C of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code and is therefore acceptable. The licensee's LEFM methodology is similar to that in the submittal dated July 9, 1998, for flaw evaluations of core shroud examination results from RF06. This methodology used the solution for a pipe with multiple through-wall cracks and then modified the solution by a factor obtained from the compound crack solution for a pipe with a 360° circumferential flaw, a portion through-wall and the rest part-through, to account for the effect due to part-through flaw geometry. The detailed staff evaluation of the licensee's LEFM methodology can be found in a safety evaluation (SE) dated October 15, 1998. In addition to the comments already made in that SE, the staff has additional comments (below, Sections 2.2.1 and 2.2.2).

2.2.1 Determination of the Initial Flaw Depth

It should be noted that in the licensee's LEFM evaluation for RF07, the average crack depth (0.58 inch) is defined differently from that of RF06. In the previous analyses for RF06, the licensee used 0.5 inch as the initial flaw depth, which is 28.2 percent larger than the average flaw depth of 0.39 inch. For the current analyses, the licensee clarified in the supplement dated October 23, 2000, that the average flaw depth for RF07 UT results is actually 0.46 inch, and the initial flaw depth of 0.58 inch used in the current LEFM analysis provides approximately the same margin over the average flaw depth when compared to the LEFM analysis of RF06. The staff determined that the licensee's determination of the initial flaw depth, which may be considered as adding a margin (approximately 26 percent) to the average flaw depth, is reasonable. The staff's determination is supported by the following: (1) there is a depth uncertainty of 0.108 inch and a length uncertainty of 0.364 inch to cover the uncertainty in measurements, (2) the growth from RF06 to RF07 is 0.07 inch (i.e., from 0.39 inch to 0.46 inch) for the average flaw depth, much smaller than the assumed growth of 0.80 inch for one fuel cycle, and (3) the licensee assumed that all weld segments that had not been examined due to

accessability problems were through-wall cracks. All these suggested that using the maximum measured depth for the initial flaw depth is overly conservative and averaging the measured flaw depths with an additional margin of 26 percent appears to be a reasonable approach.

2.2.2 Determination of Operating Hours for a Fuel Cycle of 24 Months

The licensee used 16,000 hours as the operating time for a fuel cycle of 24 months as opposed to the 17,000 hours used in the previous evaluations for RF06. Using less operating time for a fuel cycle would produce less flaw growth at the end of the cycle. Information in the licensee's October 23, 2000, supplement indicates that the revised lower operating hours for one fuel cycle bound both actual plant data for cycle 7 and projected hours for cycle 8 for the unit. Therefore, it is acceptable for the present application. The use of 16,000 hours for cycle 9 and 10 is also adequate considering that the safety margin of 5.11 for weld H5 is large enough to cover any uncertainty in the estimate.

3.0 CONCLUSIONS

The staff has reviewed the licensee's submittal. The staff determined that the limit-load analysis for multiple flaws meets the intent of the rules of the ASME Code. Further, based on the staff's evaluation of the licensee's LEFM methodology documented in the SE dated October 10, 1998, and the evaluation in Sections 2.2.1 and 2.2.2 above, the staff determines that the licensee's LEFM analysis is acceptable. Since the final multiple, part-through flaw configurations at the end of cycle 8 have safety factors of 8.58 (when the limit load analysis is applied) and 3.01 (when the LEFM is applied) for weld H4, and 5.11 (when the limit load analysis is applied) for weld H5, all exceeding the Code-required safety factor of 2.77, the staff agrees with the licensee's conclusion that the unit may be operated without repairing weld H4 for one fuel cycle and weld H5 for three fuel cycles.

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Date: October 30, 2000

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