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Sincerely,

M P Manahan, Sr.

Michael P. Manahan, Sr.
President

MPM/cjw

cc: Mr. Donald S. Brinkman

915 Pike Street, PO Box 840
Office (814) 234-8860
Lemont, PA 16851-0840
Fax (814) 234-0248
U S A

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Response to Request for Additional Information Regarding Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors"

INTRODUCTION

The NMP1 plant-specific shroud cracking safety assessment concluded that 360° cracking to some extent in the H1 through H7 circumferential welds was likely, but through-wall 360° cracking that threatens the shroud structural integrity was extremely unlikely considering operation until the scheduled February 1995 refuel outage. The BWRVIP generic safety assessment recommended that plants in the NMP1 susceptibility grouping review Fall inspection data to assess the uncertainty in estimating potential shroud cracking. The intent of this review is to ensure that the conclusions regarding adequate structural margin integrity remain valid.

The NMP1 shroud cracking safety assessment concluded that the Oyster Creek Fall 1994 shroud inspection would provide particularly valuable data to further evaluate the uncertainty associated with the conclusions that 360°, greater than 90% through-wall cracking was extremely unlikely at NMP1 considering operation until the scheduled February 1995 refuel outage.

This supplement provides the analyses and conclusions of Niagara Mohawk's assessment of the Oyster Creek shroud inspection results. In addition, the potential consequences of a 360° through-wall crack at the H4 weld during both normal, transient and accident conditions are compared to the previously evaluated limiting H3 weld location. The precautionary measures that will be adopted to provide operator guidance for detection and mitigative actions to achieve safe shutdown in the event of shroud weld separation are included. Also included is a supplemental review of the consequences of a 360° through-wall failure at weld H8 under normal, transient and accident conditions as provided to the NRC during the October 14, 1994 Niagara Mohawk presentation.

NMP1 SHROUD CRACKING SAFETY ASSESSMENT CONSIDERING THE FALL 1994 INSPECTION RESULTS

Niagara Mohawk's review of the Fall 1994 inspection data has concluded that the results are consistent with the generic assessment rankings. For example, the Monticello plant susceptibility was considered lower in the generic assessment than Oyster Creek and was found to have less significant cracking. Oyster Creek was predicted to have the potential for 360° cracking to some extent, but through-wall cracking was considered unlikely. Niagara

Mohawk's review of the available information indicates that all the inspection findings are bounded by the generic assessment susceptibility rankings. An evaluation of the Fall inspection results to date is being performed by General Electric (GE) for the BWRVIP assessment committee and will be completed by mid-November 1994. The Oyster Creek inspection results have been followed closely because of the similarities to NMP1. The following is a more detailed discussion of the Oyster Creek results.

The Oyster Creek Fall 1994 shroud inspection was a comprehensive inspection of welds H1 through H7. The extent of shroud cracking at welds H1, H2 and H3 was within the flaw screening criteria for structural integrity such that repair would not have been required for these specific welds. The inspection results for welds H5, H6a and H6b indicated no significant cracking and therefore, clearly satisfy the flaw evaluation screening criteria for structural integrity. However, the H4 weld did have significant cracking such that repair was considered the best long-term solution for Oyster Creek to ensure continued shroud structural integrity. Cracking at the H4 weld was previously evaluated by GPUN, and structural integrity was demonstrated considering operation until the September 1994 Oyster Creek refuel outage shutdown.

The results of the Oyster Creek inspection show that the cracking in the welded plate ring welds (H1, H2, H3, H6a and H6b) is well within the uncertainty considered in the NMP1 structural margin assessment. In addition, the Oyster Creek H5 shroud mid-plane plate to plate circumferential weld indicated minimal cracking indications using the OD tracker UT inspection device. However, the H4 mid-plane weld inspection performed using the OD tracker UT device indicated cracking along the weld fusion zone on both the ID and OD for a significant length of the weld surface. Therefore, the cracking at the H4 weld is considered by Niagara Mohawk to represent the only finding which warrants detailed analysis to determine the implications regarding the NMP1 shroud integrity. The following analyses concentrate on the H4 weld, however, the evaluation and screening criteria for the NMP1 shroud show that the H4 weld bounds the H3 weld and the safety significance of the H3 and H4 welds bound welds H1 through H7. Therefore, the structural integrity determination based on the worst cracking found at Oyster Creek at the H4 location bounds similar cracking at the other shroud weld locations (H1 through H7).

Two independent evaluation techniques have been applied to determine if the Oyster Creek H4 weld inspection results would cause a significant increase in the probability that the NMP1 core shroud could fail to meet its design basis structural integrity margins considering operation until the scheduled February 1995 refuel outage. These analyses have concluded that more than adequate structural margin exists for the NMP1 core shroud to justify continued operation for this time period. The detailed analyses are included as Attachments 1 and 2. The analyses approaches and conclusions are summarized below.

<u>NMP1 STRUCTURAL INTEGRITY ASSUMING OYSTER CREEK SHROUD CRACKING (GENE REPORT 523-A161-1094, ATTACHMENT 1)</u>

An independent evaluation was performed by GE to determine if the shroud cracking susceptibility factors present at Oyster Creek would bound NMP1. The conclusions of this evaluation are that a one-on-one comparison between the operating history of NMP1 and

Oyster Creek strongly suggests that NMP1's shroud is bounded by Oyster Creek's shroud condition. The shroud materials are virtually identical in the two plants. Also, NMP1's shroud corrosion performance is favored by the plant's lower first five-cycle mean conductivity, lower total mean conductivity and lower fluence at the shroud.

GE has performed a flaw evaluation of the Oyster Creek H4 weld crack indications. The evaluation incorporated conservative assumptions intended to bound the uncertainties associated with the potential NMP1 cracking at the H4 weld. The Oyster Creek cracks were conservatively treated as follows: 1) for the areas not inspected, through-wall indications were assumed; 2) each indication was characterized by the maximum depth over the entire indication; 3) a crack depth uncertainty factor of .3" was added to the depth of each crack; 4) at locations where both ID and OD cracking was found, the depth was assumed to be the sum of the maximum of each over the entire length; 5) when flaws were combined due to proximity, the maximum depth of the combined indications was used; and 6) an estimated crack growth until the next inspection (with a crack growth rate of 5×10^{-5} in/hr) was added to each crack depth. Consistent with ASME Section XI values, the safety factors applied were 2.8 for operational conditions and 1.4 for faulted conditions. The results satisfy the required margins with safety factors of 6.5 and 3.5, respectively.

To satisfy the conservatism in the assumed crack growth rates, GE completed a PLEDGE crack growth rate model prediction for NMP1. The NMP1 plant-specific calculation using the recent NMP1 water conductivity and current fluence at the H4 weld shows a crack growth rate of 2.6×10^{-5} in/hr. This calculation demonstrates that the 5×10^{-5} in/hr crack growth rate used for structural integrity analysis is quite conservative.

The overall conclusion of the GE evaluation is that shroud cracking sufficient to reduce the structural margin below the required safety factors is extremely unlikely at NMP1 considering operation through the end of February 1995. This analysis demonstrates that continued operation of NMP1 is justified based on the continued structural integrity of the NMP1 shroud considering the results of the Oyster Creek shroud inspection.

NMP1 SPECIFIC H4 WELD CRACKING ASSESSMENT (MPM REPORT MPM-109439, ATTACHMENT 2)

A detailed NMP1-specific fracture mechanics assessment of the H4 weld has been completed. This analysis includes the derivation of the H4 weld residual stress profile based on the NMP1 shroud fabrication records. These records provide excellent details on the welding procedure, the welding sequence, the heat inputs, and non-conformances. From these records a weld simulation analysis resulted in an H4 NMP1-specific weld residual stress profile. Using this stress profile, crack initiation and crack growth calculations were performed to determine the probability that the NMP1 shroud could have cracking at the H4 location which could impact the required structural integrity of the shroud. This analysis included a thorough assessment of the neutron fluence at the H4 location and its affect on crack initiation and growth and consideration of fabrication anomalies, including undocumented, but industry standard practices typically used in vessel fabrication at that time. This analysis also applied plant-specific electrochemical corrosion potential (ECP) data to define a NMP1-specific crack growth rate independent of the GE PLEDGE model.

This analytical treatment of the NMP1 H4 weld has provided valuable insight into the potential for cracking at the H4 location and into the potential reasons for the cracking found at the Oyster Creek H4 location. The fundamental finding of this study is that the potential is high for ID-initiated cracking at the NMP1 H4 weld location as a direct consequence of the fabrication procedure used by P.F. Avery. This welding procedure results in an ID surface stress intensity comparable to the stress intensity required for stress corrosion cracking initiation. This analysis also shows that the stress intensity on the OD surface is generally not sufficient to cause OD-initiated cracking at the H4 weld and that to create conditions which could initiate OD cracking, additional fabrication anomalies and/or initial flaw assumptions are required. The crack growth simulation assuming an ID-initiated flaw shows that the crack would not exceed an average depth of .4 inches. The overall conclusion of this study is that based on the NMP1 shroud fabrication records, the NMP1 H4 weld cracking could be predicted to be ID-initiated up to 360°, with an average depth of .4 inches. This finding is generally consistent with the Oyster Creek H4 weld cracking which had significantly more ID-initiated cracking than OD-initiated cracking.

OD-initiated cracking at the NMP1 H4 weld however, cannot be ruled out for several reasons, the most obvious being that Oyster Creek did have significant OD-initiated cracking. Several conditions can be postulated to cause OD cracking, including deep initial flaws which escape detection during the liquid penetrant testing of the weld during the fabrication process. The potential for flaws in excess of .010 inches deep to go undetected following the documented liquid penetrant test is considered highly unlikely and therefore, flaws greater than .010 inches in depth were not postulated. The crack growth predictions for NMP1 assuming this initial flaw size show small crack depths through the end of cycle 11 (February 1995) when only the welding residual stresses are applied.

The most difficult condition to predict is fabrication fit-up induced stresses which result from ovality mismatch (general out-of-round conditions), plate runout, weld pass starting and stopping, jacking for fit-up, localized grinding, localized weld repair, etc. The potential weld fit-up type of induced residual stress profiles and circumferential variation due to weld pass start/stop have been simulated to quantify the probability of OD crack initiation and the potential for this cracking to propagate through-wall at the H4 location. The results of this study show it is extremely unlikely that these types of conditions could result in 360° through-wall cracking. The model developed to characterize these effects conservatively shows that 41% of the section would remain uncracked at the end of cycle 11. Structural margin analysis cases demonstrate that the required margins are more than satisfied for this potential cracking condition.

Because of these analytical results, the NMP1 fabrication records were compared to the Oyster Creek fabrication records. The fabrication records show that the Oyster Creek shroud was completed prior to the NMP1 shroud and imply some lessons learned may have benefitted the NMP1 shroud. These records document that the Oyster Creek fit-up resulted in an overall mismatch between the upper and lower shroud sections, resulting in a top guide plate to core plate misalignment which required corrective action. Since the H4 weld was the weld which connected the upper and lower shroud sections, this condition could have resulted from a fit-up problem at the H4 weld. The NMP1 shroud records do not indicate a similar problem and include documentation of ID measurements taken in the vicinity of the

H4 weld which satisfied the design specifications of 176 $\pm$ 1/2 inch. Review of the records in general indicate fewer fit-up problems for the NMP1 shroud. In addition, the Oyster Creek Fall 1994 inspection and repair have documented circumferential variations in the vicinity of the H4 weld and have also documented the vertical shift between the upper and lower shroud. This information provides an additional basis for the conclusion that, at a minimum, the NMP1 shroud fabrication is bounded by the Oyster Creek shroud considering fabrication fit-up type of induced stresses.

The overall conclusion reached from this analysis is that cracking at the H4 weld location is likely. However, it is extremely unlikely that the cracking at the NMP1 H4 weld has progressed such that structural integrity of the H4 weld would not satisfy the required margins considering continued operation of NMP1 until the scheduled refuel outage in February 1995.

OPERATOR GUIDANCE FOR DETECTION OF THROUGH-WALL CRACKING

Enclosed as Attachment 3 is Special Operating Procedure N1-SOP-2, "Unexplained Reactor Power Change." This procedure is included in the current operator requalification training cycle scheduled to be completed by mid-November 1994. This procedure incorporates the expanded guidance provided by the BWROG for shroud through-wall cracking detection and NMP1 plant-specific guidance for shroud weld failure corrective actions.

SAFETY CONSEQUENCES OF H4 THROUGH-WALL 360° CRACKING

Review of the H4 weld location confirms that the consequences of 360° through-wall cracking at H4 are bounded by the consequences of the H3 weld cracking. The H4 weld is located ~18 inches below the H3 weld location which results in an additional weight estimated at 5000 lbs. The consequences during normal operation, transient and accident conditions previously evaluated are approximately equal for the H3 and H4 locations. The NMP1-specific main steam line break (MSLB) RELAP analysis evaluated the potential shroud lift assuming H3 weld location 360° through-wall cracking. This study included a weight sensitivity that shows that the additional 5000 lbs reduces the total lift from ~12.1 inches to ~11.8 inches. Safe shutdown of the reactor is assured considering these limiting conditions.

Additional detailed safety analyses applicable to NMP1 for the MSLB using the TRACG analysis approach are in progress by GE Nuclear Energy through the BWRVIP. These analyses are expected to be completed by the first week of December 1994 and will provide an independent detailed analysis of the MSLB accident pressure loads and the corresponding potential shroud lift, assuming the limiting H3 weld is cracked 360° through-wall.

SUPPLEMENTAL REVIEW OF THE CONSEQUENCES OF A 360° THROUGH-WALL WELD FAILURE AT THE H8 LOCATION

During an October 19, 1994 telecon, the Staff asked if Niagara Mohawk would be revising the inherent jaggedness discussion for weld H8 contained in our September 26, 1994 submittal based upon the more recent information provided during the October 14, 1994

presentation at NRR Headquarters. The information provided below amends our September 26, 1994 response to Information Request 3 for weld H8.

The detailed analysis of the H8 weld demonstrated that through-wall cracking through the plane of the H8 weld was not credible. This detailed analysis also predicted that if a circumferential crack is forced to initiate and propagate through the H8 plane 360°, the crack would tend to separate on the order of 1/8 inch. This analysis result demonstrates that through-wall conditions at the H8 weld would be detectable by the operator and corrective actions would be taken to safely shut down the reactor. This analysis also indicates that visual inspections of H8 would have detected gross cracking at the H8 weld since the postulated H8 crack would tend to separate.

In the incredibly unlikely event that an undetected 360° through-wall crack did develop in the H8 weld prior to the scheduled 1995 refuel outage and a double ended guillotine recirculation line break occurred, the shroud should still be prevented from dropping because of the two conditions created during the LOCA: 1) the asymmetric load on the shroud would tend to bind the shroud at the H8 plane and at the 129 guide tube locations which have between a .03 and .06 inch diametric clearance and 2) the blowdown pressure differential on the core plate produces a downward.force simultaneously on the cone, forcing the support cone and support ring together at the H8 weld plane. Because of these two factors, it is highly unlikely that the core shroud could drop during a LOCA. Following the blowdown, no significant downward force is exerted on the shroud. Therefore, the shroud is expected to remain wedged at the cone and guide tubes such that the core spray spargers remain functional.

CONCLUSION

The detailed NMP1 analyses performed to address the implications of the Oyster Creek shroud inspection results confirm the NMP1 generic letter submittal conclusion that continued operation of NMP1 is justified until the scheduled February 1995 refuel outage. This conclusion remains valid based on the extremely low probability that the core shroud would fail to meet its design basis structural integrity margin during this time period, coupled with the extremely low overall probabilistic risk estimate.

ATTACHMENT 1

NINE MILE POINT UNIT 1
DOCKET NO. 50-220
LICENSE NO. DPR-63

GENERIC LETTER 94-03
SUPPLEMENTAL INFORMATION

"STRUCTURAL EVALUATION AND JUSTIFICATION OF THE NINE MILE POINT UNIT 1 CORE SHROUD FOR CONTINUED OPERATION"

GENE-523-A161-1094
GE NUCLEAR ENERGY

CDT/AER/lmc
Enclosure

xc: Regional Administrator, Region I
Mr. L. B. Marsh, Director, Project Directorate I-1, NRR
Mr. D. S. Brinkman, Senior Project Manager, NRR
Mr. B. S. Norris, Senior Resident Inspector
Records Management