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AUTH.NAME AUTHOR AFFILIATION
TERRY,C.D. Niagara Mohawk Power Corp.
RECIP.NAME RECIPIENT AFFILIATION
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NIAGARA MOHAWK POWER CORPORATION/301 PLAINFIELD ROAD, SYRACUSE, N.Y. 13212/TELEPHONE (315) 474-1511

September 26, 1994
NMP1L 0863

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

RE: Nine Mile Point Unit 1
Docket No. 50-220
DPR-63

Subject: *Response to Request for Additional Information Regarding Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors" (TAC No. M90102)*

Gentlemen:

By letter dated August 23, 1994 (NMP1L 0852), Niagara Mohawk provided a response to Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors," for Nine Mile Point Unit 1 (NMP1). By letter dated September 16, 1994, the Staff requested that Niagara Mohawk submit additional information in order to complete the review of Niagara Mohawk's response. Enclosed is Niagara Mohawk's response to the Staff's September 16, 1994 request for additional information.

Based on analyses performed to date, the lack of crack indications during previous shroud inspections and NMP1's redundant safety features, the continued operation of NMP1 until the scheduled February 1995 refueling outage does not pose a significant risk to the health and safety of the public.

Very truly yours,

C. D. Terry
Vice President - Nuclear Engineering

CDT/AER/lmc
Enclosure

xc: Regional Administrator, Region I
Mr. M. J. Case, Acting Director, Project Directorate I-1, NRR
Mr. D. S. Brinkman, Senior Project Manager, NRR
Mr. B. S. Norris, Senior Resident Inspector
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NINE MILE POINT UNIT 1
DOCKET NO. 50-220
DPR-63
TAC NO. M90102

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

<u>Information Request 1</u>

"Specifically, the licensee used Oyster Creek's RELAP 5 model to assess the consequence of a main steamline break (MSLB). The licensee did not specify why Oyster Creek's model was used and not a plant-specific model. The Staff did not agree with Oyster Creek's conclusion that 0.025 inches provided sufficient margin of safety to consider the postulated MSLB with a 360° through-wall crack as not significant. Niagara Mohawk Power Corporation (NMPC) should perform a plant-specific consequence assessment to ensure that the top guide will not clear the top of the active fuel during an MSLB."

<u>Response 1</u>

<u>Plant Specific Assessment</u>

Oyster Creek's model was used because it was determined to adequately represent Nine Mile Point Unit 1 (NMP1) for the purpose of the shroud cracking safety assessment. In this regard, NMP1 and Oyster Creek are sister BWR-2 plants. The reactor vessel, internals (shroud, separators, dryer, top guide) and the main steam line configuration (two 24 inch diameter main steam lines) are identical between the two plants. The core rated power and rated steam flow are very similar. The differences between the two plants, relevant to the shroud differential pressures, are the core inlet orificing and rated core flow. The NMP1 inlet orificing is lighter, resulting in a reduced core differential pressure compared to Oyster Creek.

As discussed in the Second Supplement to the NMP1 FSAR, the lighter orificing results in differential pressures which are lower for the shroud support, core support plate, and guide tube, but slightly higher for the fuel channels. Steam separator flow is increased, resulting in a slight increase in differential pressure applied to the upper shroud. This slightly increased separator flow is minor due to the similar rated steam flow conditions (i.e., rated power for Oyster Creek is 1930 MWt, 7.25 Mlb/hr versus 1850 MWt, 7.31 Mlb/hr for NMP1).

Based on this information, the Oyster Creek RELAP analysis of the consequences of a main steam line break is considered applicable to NMP1 and therefore, was referenced in our Generic Letter (GL) 94-03 response and represented the best information available within the 30 day response time of the GL. As stated in our GL response, Niagara Mohawk is participating in the BWRVIP effort to develop detailed

analyses of the shroud loads for use in repair plans, flaw evaluation and 360° through-wall evaluations. These detailed analyses are intended to provide bounding product-line analyses which can be referenced as applicable plant-specific analyses.

Requested Additional Information

To further support the applicability of the Oyster Creek RELAP analysis, additional cases have been completed which model the NMP1 specific power, core flow, steam flow and core differential pressure. These RELAP cases demonstrate similar shroud head lifts assuming 360° through-wall separation at the H3 weld. Niagara Mohawk considers the Oyster Creek RELAP analysis methodology applying the NMP1 specific initialization and 360° through-wall crack assumptions as the best NMP1 plant-specific analysis available until BWRVIP analyses are completed. It is Niagara Mohawk's intent to complete a detailed analysis of the shroud response to both MSLB and Reactor Recirculation Loss of Coolant Accident (RRLOCA) through the BWRVIP when the analysis methods have been developed and accepted through the BWRVIP assessment subcommittee initiatives. A schedule for these analyses is currently being finalized. It should also be pointed out that the NMP1 specific RELAP analysis case is intended to support a justification for continued operation and is not intended to provide any long term NMP1 safety or design basis.

The Oyster Creek analysis quoted a top guide lift assuming an instantaneous double-ended guillotine break (DEGB) of the main steam line and indicated that this is a very conservative assumption. As discussed in NUREG-0609, Appendix C, break opening times can be expected to be significantly greater than 10 msec. Based on this information and discussion with General Electric, a 50 msec break opening time is considered a justified realistic assumption for the purpose of this assessment. In addition, the core spray piping provides restraint to limit the magnitude of the lift of a separated shroud at the H3 weld which was not included in the Oyster Creek maximum lift.

Assuming a break development time of 50 msec and the restraint of the core spray piping, the NMP1 plant-specific RELAP analysis demonstrates that the displacement would be less than that required to clear the top of the fuel channels. Specifically, the maximum expected top guide lift is 12.1 inches. A lift of 13.3 inches is needed to clear the top of the fuel channels. In addition, the Oyster Creek RELAP analysis conclusion that the shroud would return to rest with a force no greater than its weight and will not impart significant loads to the reactor vessel has been confirmed to be applicable to NMP1. Additional sensitivity studies show that break locations downstream from the main steam line nozzle reduce the potential top guide lift significantly (e.g. moving the break location 28 feet from the nozzle reduces the potential lift to approximately 6 inches). Sensitivity studies also show that realistic break development times approaching 100 msec would reduce the total lift of 12.1 inches by approximately 1.5 inches.

Additional Supporting Information

Additional margin is also provided by the fuel bundle handles. These handles rise approximately 4 inches above the top of the fuel channel. The handle orientations are such that the fuel bundle geometry is maintained even if the top guide is postulated to rise above the fuel channel. An approximate 2 inch maximum lateral displacement at the top of the bundle could occur since the handles are inset and oriented forming a square for each cell. This would not result in a misalignment which could prevent rod insertion. The condition would result in additional friction which would slow control rod insertion speed; however, the MSLB accident does not depend on rapid scram to mitigate the event. Therefore, slow rod insertion would have no impact on the fuel cladding integrity for this event. These bail handles also insure that the overall core geometry is maintained, which ensures that the Standby Liquid Control (SLC) System would function as designed if incomplete rod insertion is postulated. In addition, the duration of the maximum lift above 10 inches is calculated to be less than 100 msec, and the fuel would be expected to maintain its vertical alignment since no significant lateral force exists. The hydraulic dampening due to the vertical flow in both the bypass and fuel channels is significant such that the fuel bundles would not be expected to react in 100 msec even if a lateral force is postulated.

The NMP1 plant-specific analysis confirms the generic conclusions that a 360° through-wall crack at the limiting H3 location is detectable. The total normal steady state power lift was estimated at 1.6 inches, neglecting core spray pipe stiffness. The core spray pipe stiffness is not expected to be adequate to hold the shroud in a tight crack during normal operation, and therefore, the shroud is expected to lift on the order of 1/2 inch. This amount of lift has previously been estimated to result in a power reduction transient on the order of 5% to 15% of rated. The detectability of this situation is further supported by shroud head lifts during normal operation which have occurred in 1984 and 1991 at other BWRs because of improper engagement of shroud head bolts, resulting in power anomalies which were detected.

As stated in the NMP1 GL 94-03 response, control rod insertion is not expected to be impacted since the fuel alignment is maintained. The core spray lines are expected to be damaged by the displacement, and the damage is expected to affect core spray sparger injection. However, the ability of core spray to inject to the vessel downcomer region and or core spray sparger would be expected to be maintained to some degree. Since the amount of core spray flow needed to provide core coverage is minimal, no impact in overall core cooling exists. The High Pressure Coolant Injection System is also available to provide adequate makeup to mitigate the MSLB accident. In addition, the probability of a MSLB is low due to, among other things, the limited number of welds between the reactor pressure vessel and the flow limiter and the inclusion of these welds and piping in the ASME Section XI Inspection Program. The MSLB outside the flow limiter is not a significant concern relative to the shroud issue because, per Chapter XVI of the NMP1 Updated FSAR, the flow is reduced to 67% of the value from a break inside the flow limiters which greatly reduces the shroud lift, providing margin to ensure the fuel remains in proper alignment.

Furthermore, the PRA assessment has shown that whether the top guide will clear the top of the fuel channels is not a significant contributor to overall core damage frequency. If the top guide clears the top of the fuel channel, the SLC System can be used for reactivity control by augmenting what may be only a partial control rod insertion. In terms of a severe accident scenario, the failure of SLC must occur coincident with a MSLB and shroud failure. Combining the probability of these events, as documented in the PRA submitted in the NMP1 GL 94-03 response, results in an incremental core damage frequency of 1.2E-10 per year. This very low probability suggests that the postulated MSLB-shroud event is of negligible risk significance. In addition, in the unlikely event that SLC fails coincident with a MSLB and shroud failure, the Emergency Operating Procedures provide a means to successfully mitigate the event using injection (i.e., core spray) and containment heat removal (i.e., containment spray and containment spray raw water).

Niagara Mohawk has not credited a postulated leak-before-break scenario in the above discussion. As stated in the Bases for NMP1 Technical Specification Section 3.2.5, "Reactor Coolant System Leakage," the behavior of pipe cracks has been experimentally and analytically investigated. These studies and subsequent NUREG-1061 studies demonstrate that guillotine breaks are extremely unlikely and that pipe cracking leakage can be detected before the crack grows to a dangerous or critical size. The Bases for Section 3.2.5 also states that any leakage in excess of 15 gpm steam would cause a continuing increase in drywell pressure with resulting scram. Therefore, there is a very high likelihood that should a DEGB break begin to occur, the reactor would be shutdown prior to challenging shroud welds to the point where they could fail regardless of the extent of cracking.

Conclusion

Considering the information presented above, the consequences of a weld failure at H3 would not create a condition which would prevent control rod insertion or prevent adequate core cooling. Also, while it cannot be ruled out with certainty, cracking of the H3 weld at greater than 90% through-wall and 360° is considered to be very unlikely. Therefore, continued operation of NMP1 until the February 1995 refueling outage does not pose a significant risk to the health and safety of the public.

Information Request 2

"The licensee did not perform a plant-specific assessment of any structural loadings due to a seismic event, a seismic event plus a recirculation line break (RLB), and a seismic event plus an MSLB. NMPC should perform a consequence assessment of seismic events stated above to ensure core spray operability and control rod insertion assuming a 360° through-wall crack."

Response 2

Plant-Specific Assessment

The NMP1 GL 94-03 response addressed shroud response to the seismic design basis loads by reviewing the General Electric BWR Shroud Cracking Generic Safety Assessment (GENE-523-A107P-0794) evaluation of the effect of seismic loads on shroud displacement.

The General Electric assessment concludes that for welds below the core plate, both the tipping and vertical displacement is limited to 1/2 inch because of the core support plate to fuel support structures clearances, and less than 1 inch in the lateral direction. For welds above the core plate, the maximum lateral seismic motion was determined to be 1 inch and this displacement was momentary. General Electric stated that a less than 1 inch seismic induced lateral movement will not prevent control rod insertion and that control rod insertion will occur as seismic oscillations will realign the guide tubes and fuel support structures. For this maximum displacement, both the ECCS injection and SLC function is not impacted. The seismic plus recirculation line LOCA was less limiting because all the shroud welds are in compression due to the downward pull, which prevents both vertical and lateral displacement. The lateral seismic loads combined with the asymmetric blowdown loads could lead to a momentary tipping. However, the restoring moment of the shroud weight prevents permanent displacement and control rod insertion and ECCS and SLC injection are not impacted.

Requested Additional Information

In response to the request for additional information, the NMP1 specific seismic loads being developed for the NMP1 contingency shroud repair have been used by General Electric to quantify the maximum shroud displacement for the NMP1 Design Basis Earthquake (DBE) for the NMP1 design basis load combination of normal plus transient assuming 360° through-wall cracking. The results confirm that control rod insertion, core spray and SLC functions are maintained.

A detailed computer model was utilized, which included the reactor building, shield wall and pedestal, reactor pressure vessel, reactor internals and the licensing basis DBE time history load applied. The resultant response time history of the displacements at the top guide and the core plate were generated. Review of the response time history shows that the displacement of the top guide relative to the core plate reaches a maximum value of 2 inches at 7.5 seconds after the onset of the DBE. For this lateral displacement, tests have shown the ability to fully insert control rods. Since the control rods will insert fully within the 7.5 second period, there are no safety implications relative to scram ability from a DBE.

A simple static calculation was performed to determine the restoring effects of the vertical inertia of the shroud against the tipping effects of the seismic load, for the most limiting 360° through-wall crack location (H7). This calculation indicates that

the lateral load due to the seismic event will not overcome the restoring moment due to vertical inertia. As a result, tipping is deemed not possible and thus impairment of control rod insertion during a scram, due to excessive displacement, is deemed unlikely.

The MSLB or RLB event coincident with the DBE is beyond the design basis of NMP1. These coincident events can best be treated, at least initially, using PRA. Due to the low likelihood of each individual event, the coincident occurrence of the DBE and a large break is considered very small. Even if it were conservatively assumed that core damage would result if a DBE and large break occurred during the same day, a core damage frequency estimate of less than 1E-10 per year results.

Additional Supporting Information

The physical attributes in the annulus between the RPV and the shroud near the shroud head region were also investigated. At the shroud head flange, in the 0-180° diametrically opposite orientation, two 6.5" x 11" x 4" thick lugs exist. The clearance between the lug and the RPV wall inner surface is 1 inch. This would limit the displacement of the shroud at the top guide elevation to less than 1 inch in the 0-180° direction. In the 60-240° diametrically opposite orientation, core spray piping penetrates the RPV and runs vertically down the annulus for 18 inches and is welded to the sleeve at the shroud head flange. This 6 inch diameter schedule 40 piping provides substantial stiffness/restraint in the lateral direction in the 60-240° orientation. In any other diametrical orientation, due to the stiffness component of the core spray line penetrations and the clearance limitations at the lugs described above, there is considerable restraint against displacement, limited to about 1 inch at the top guide location.

The above analysis is corroborated by the NRC in its July 21, 1994 letter from J. F. Stang to D. L. Farrar, "Resolution of Core Shroud Cracking at Dresden, Unit 3, and Quad Cities, Unit 1." In this letter the NRC concluded that, assuming a 360° through-wall crack, an SSE would not affect control rod insertion, core reflood, core spray, or SLC for Dresden and Quad Cities. Given that NMP1 has, in general, a similar shroud design, the NRC's conclusion validates Niagara Mohawk's above conclusions for the NMP1 DBE response. In addition, the above NRC letter indicated that seismic-shroud events of potential risk significance are limited to those potential events where a SSE occurs coincident with a MSLB or RLB.

Conclusion

Therefore, seismic events pose very little risk relative to the postulated shroud failure events. This risk is reduced even further as a 90% through-wall 360° crack is considered very unlikely.

Information Request 3

"Furthermore, the licensee did not assess a postulated 360° through-wall crack at the H8 weld during an RLB at Nine Mile Point Nuclear Station Unit No. 1 (NMP-1). The licensee did not believe that this was a credible failure. The licensee stated that cracking in H8 would have to be about 90 percent through-wall for 360° in order for H8 to fail during an RLB. The staff questions why continued operation of NMP-1 is justified if a 360° crack that is 90 percent or greater through-wall is present at the H8 weld. The licensee did not evaluate the acoustic and blowdown loads associated with the RLB. NMPC should justify continued operation assuming a 360° through-wall crack at the H8 weld."

Response 3

Plant-Specific Assessment

Item 2b of GL 94-03 requested a plant-specific assessment accounting for the uncertainties in the amount of cracking. This assessment was to include the shroud response to design basis events (e.g., steam line break and recirculation line break), and if asymmetric loads can affect the shroud response these loads should be considered. For these loadings, the ability of the safety features to perform their function was to be assessed. Appendix A of the NMP1 GL 94-03 response included an assessment of the uncertainty in the amount of cracking at the H8 weld. This assessment concluded that the uncertainty in the amount of cracking at H8 was extremely low, such that a 360° through-wall crack was not a credible assumption considering continued operation to the scheduled February 1995 refueling outage. Niagara Mohawk's interpretation of the GL requirements for plant-specific 360° through-wall crack analyses is consistent with other BWRs with shroud welds classified in the extremely unlikely category (i.e., plants in this category have not completed plant-specific 360° through-wall coping analyses).

Sections 2.0, 3.0, and Appendix A of the NMP1 GL 94-03 safety assessment provided a detailed plant-specific safety assessment of the H8 weld. Niagara Mohawk considers this plant-specific H8 weld assessment as comprehensive and sufficient to conclude that the uncertainty in the degree of cracking at H8 is extremely low. This conclusion is based on both ASME Section XI weld inspections of all accessible areas of the H8 weld and detailed analysis of the H8 weld susceptibility. H8 weld inspections were performed in 1993 as specified by ASME Section XI. These inspection tapes were subsequently reviewed by an NMPC level III qualified examiner concurrently with a GE level III qualified examiner, who participated in the examination activities at Quad Cities and Dresden and who is qualified to the enhanced level proposed by the BWRVIP. The original and subsequent review of these inspection tapes completed for this plant-specific assessment concluded there was no evidence of cracking.

The H8 weld fabrication and susceptibility was described in detail in Section 2.3.1 and Appendix A of our GL 94-03 response. The H8 weld attaches the type 304 forged stainless steel shroud support ring to the alloy 600 support cone. This weld

was an original vessel fabrication shop weld which was post-weld heat treated, such that residual stresses were significantly reduced. The detailed analysis of this weld condition was documented in Appendix A. The conclusions reached in this analysis are that a low tensile stress exists (maximum 13 KSI) and this maximum stress exists at the location of the ASME Section XI inspections. In addition, cracking in the heat affected zone of the supporting ring adjacent to weld H8 would grow very slowly, if at all, because: (1) it would have to grow into an area of applied compressive stresses; and (2) weld residual stresses are also expected to become compressive in the ring at the center of weld H8.

Based on the analysis submitted in the NMP1 GL 94-03 response, Niagara Mohawk considers the assumption of a 360° through-wall crack at the H8 location as a beyond design basis assumption which is not credible based on ASME Section XI code required inspection results and detailed weld condition assessment.

In the improbable event a 360° through-wall crack did develop in the H8 weld prior to the scheduled February 1995 refueling outage, an upward displacement (up to 1/2 inch) will likely result at high power and flow operation. This upward displacement will result in sufficient core bypass leakage flow through the shroud support cone into the annulus region resulting in power anomalies. These anomalies would likely be detected and normal shutdown carried out. As stated in the NMP1 GL 94-03 response, plant operators have been trained and operating procedures have been revised to alert operators of the expected plant response should a through-wall shroud crack develop.

<u>Requested Additional Information</u>

Even in the incredibly unlikely event that an undetected 360° through-wall crack did develop in the H8 weld prior to the scheduled February 1995 refueling outage and a recirculation line break (RLB) occurred, the shroud should still be prevented from dropping because:

1. Our response to the GL indicated that a remaining ligament of only 1/4 inch is required in the H8 weld to support the RLB load. The postulated crack is an approximate 2 inch deep intergranular stress corrosion crack which by definition is a jagged crack. The inherent jaggedness of the intergranular cracked surfaces postulated in the H8 weld could be demonstrated to have a significant shear load carrying capability to resist the downward displacement of the shroud.

2. The finite element stress analysis of the H8 weld between the shroud support ring and the inconel shroud support cone indicates that the inconel cone is very flexible. As such, the interlocking nature of the jagged surfaces would resist shear and produce a downward motion of the flexible cone, causing a wedging effect that would prevent the shroud from dropping

during the RLB. Furthermore, the asymmetric loads on the shroud caused by the RLB are thought to impose tipping loads on the shroud. As mentioned below, the asymmetric loading interval is very short and is not sufficient to tip the shroud. However, a small amount of lateral force could enhance this wedging effect and prevent the downward vertical displacement of the shroud.

3. Our response to the GL indicated that the finite element stress analysis of the H8 weld showed that the normal operating stresses in the weld are generally compressive due to the difference in thermal expansion coefficients of the support ring and support cone. These thermal stresses would tend to keep the postulated 360° jagged crack closed, thereby maintaining the shear load carrying capability of the jagged crack edges during a RLB.

Based on the above qualitative assessment, the downward displacement of the shroud for a postulated 360° through-wall crack at the H8 weld would be minimal and should not damage the core spray lines as was stated in the shroud generic safety assessment.

Additional Supporting Information

To further address this area, Niagara Mohawk has performed a PRA regarding the risk significance of postulated H8 weld cracks. The above-mentioned analysis and inspections were used to determine that the H8 weld failure probability was much less than 1E-3 per RLB event. Assuming core damage would result from a RLB with H8 failure, the H8 failure probability is multiplied by the probability of a RLB event, 7.51E-6 per year, which results in an increased core damage frequency of less than 7.51E-9 per year due to the shroud cracking issue.

In addition, the above does not credit a postulated leak-before-break scenario. MPR has completed an analysis for NMP1 entitled "Stability of Postulated Through-Wall Flaws in NMP-1 Recirculation System Piping, MPR-1216, December 1990," which has determined that a leak-before-break failure is much more likely than an instantaneous DEGB. As such, there is a high likelihood that the plant would be shut down due to leakage prior to an actual DEGB event.

Requested Asymmetric Loading Information

The asymmetric loads associated with a recirculation suction line break were discussed in Section 5.0 of the NMP1 GL response consistent with the affect that these loads have on the shroud response as documented in the generic assessment. The asymmetric loads (both acoustic and blowdown loads) are not defined in the NMP1 design or licensing basis. Plant-specific asymmetric loads could not be developed in time for the GL response. Our response stated that analyses are under development through the BWRVIP to adequately define these loads. A schedule for

these analyses is currently being finalized. The acoustic load is generically not significant since the duration of the load is approximately 10 ms, and this short duration is not sufficient to tip the shroud if a 360° through-wall crack did exist. The blowdown load estimates provided by General Electric for the generic submittal produce a lateral load on the shroud, however, this load is during a recirculation line double ended suction line break which produces downward load on the shroud. The blowdown load is bounded by the seismic load, which is not sufficient to displace the shroud. Any tipping would be momentary because of the restoring moment on the shroud due to its weight alone.

In response to the request for additional information, the asymmetric loads which are being defined for the contingency shroud repair under development for NMP1 have been used by General Electric to assess the impact of these loads, assuming 360° through-wall flaws. The blowdown load was analyzed by examining the expected flow pattern near the recirculation suction nozzle (H7 weld location) with a potential flow model. The analysis was conducted for subcooled blowdown conditions, when the largest load is placed on the shroud.

The lateral force on the shroud assembly above the H7 weld is 86 Kips. The corresponding blowdown moment, taken about H7, is 392 Kip-feet. This moment is much smaller than the restoring moment calculated in the seismic assessment of the shroud (3905 Kip-feet). Thus, tipping due to a lateral blowdown load is not deemed possible and impairment of control rod insertion during scram is unlikely.

Conclusion

The above assessment of the H8 weld failure potential, the PRA results, the negligible consequences of the asymmetric acoustic and blowdown RRLOCA loads, and the short period of proposed operation demonstrate that there is very little risk associated with continued operation of NMP1.