March 15, 1995

MEMORANDUM TO: Kamal A. Manoly, Section Chief
Mechanical Engineering Branch
Division of Engineering

FROM: Margaret Chatterton, Acting Section Chief
Reactor Systems Branch
Division of Systems Safety & Analysis

SUBJECT: DSSA SER INPUT REGARDING THE NINE MILE POINT 1 CORE SHROUD REPAIR (TAC #M91273)

On July 25, 1994, the staff issued Generic Letter 94-03 concerning core shroud cracking in boiling water reactors (BWRs). By letter dated January 6, 1995, as supplemented by letters dated February 24, February 28, March 6, and March 14, 1995, Niagara Mohawk Power Corporation (NMPC) submitted the details of their planned repair of the 304 stainless steel circumferential welds for the Nine Mile Point Unit 1 (NMP1) reactor core shroud. Information was also provided to the staff during conference calls held on March 1, and March 3, 1995. The permanent repair involves installation of four tie-rod assemblies combined with core plate wedges to replace w[illegible] H7 and six brackets to replace the downward vertical load capability of the H8 weld. It was NMPC's intention to examine the H1 through H8 shroud welds in accordance with the BWRVIP Inspection Criteria and install the tie-rod assemblies and/or the H8 weld brackets only if cracking was found to be unacceptable for continued plant operation. Based on the results of the ultrasonic examination of the H8 weld, NMPC decided to install the four tie-rod assemblies and not the brackets.

The Reactor Systems Branch (SRXB) has reviewed the licensee's January 6 and subsequent submittals. Our evaluation is provided in the attached Safety Evaluation Report (SER). This SER provides our input to the review being conducted by the Division of Engineering regarding the structural and materials aspects of this proposed repair. The SRXB review concerns the systems aspects of the repair including the affect of the repair on the response of the plant to normal, transient and accident conditions.

Docket No.: 50-220

Attachments: As stated

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415-3743

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NINE MILE POINT 1 CORE SHROUD REPAIR

SRXB EVALUATION

1.0 INTRODUCTION

The intent of the Niagara Mohawk Power Corporation (NMPC) design and summary reports for Nine Mile Point Unit 1, dated January 6, 1995, was to demonstrate that fuel geometry and core cooling would be maintained given the unlikely occurrence of a through-wall failure of any horizontal weld during normal operations and design basis events with the core shroud repair installed. Fuel geometry must be maintained to ensure control rod insertion while core cooling is ensured by proper emergency core cooling system (ECCS) performance. The NMPC submittals provided analyses of the principal effects and issues of operating the plant with circumferential shroud welds cracked and tie-rod assemblies and/or H8 weld brackets installed. Some of the conditions analyzed by the licensee included tie-rod system induced leakage, shroud weld crack leakage, downcomer flow characteristics, lateral displacement of the shroud, and vertical separation of the shroud. The Reactor Systems Branch has reviewed these portions of the NMPC submittal, compared the results to the original consequence assessment without the shroud repair dated August 23, 1994, and provided an evaluation of the licensee's findings in the following discussion.

2.0 EVALUATION

The proposed design of the NMP1 shroud repair consists of four tie-rod assemblies combined with core plate wedges and six H8 weld brackets. NMPC provided a summary report of the proposed core shroud repair response to normal operation and design accident loads, including seismic loads and postulated pipe ruptures.

2.1 TIE-ROD SYSTEM INDUCED LEAKAGE

The installation of the tie-rod assemblies requires the machining of eight holes in the shroud head flange and eight holes in the shroud support cone. The installation of the H8 weld brackets requires the machining of twenty four holes in the lower shroud. The licensee estimates that a small amount of core flow leakage through the clearance between the holes and the mating bolts and shear keys will occur. The total calculated leakage from the installation of the tie-rod assemblies and H8 brackets was estimated to be 0.70% of core flow at 100% rated power and 85 to 100% rated core flow. Although this leakage is not significant with regards to total core flow and would be acceptable by the staff, the staff noted that the leakage rate would be reduced with the installation of either the tie-rod assemblies or the H8 brackets. By letter dated February 28, 1995, NMPC informed the staff that the installation of brackets at the H8 weld is not necessary based on the results of the ultrasonic examination of the H8 weld. Therefore, with only the tie-rod assemblies installed, the total calculated leakage was estimated to be 0.33% of core flow at 100% rated power and 85 to 100% rated core flow. The staff does not consider this leakage rate to be significant with regards to total core flow and therefore, is acceptable.

At NMP1, the ECCS consists of the single-train feedwater coolant injection (FWCI) system, the automatic depressurization system (ADS), and the two-train core spray (CS) system. The FWCI system requires limited offsite power to be functional. During a LOCA, the core spray system transfers water from the suppression pool to the reactor vessel where the water cools the core and returns to the suppression chamber via the break. Based on the above description of the core spray, the staff notes that leakage through the clearance of the repair holes does not affect the performance of the core spray system. Therefore, ECCS performance is not affected by the physical installation of the tie-rod system and/or the H8 weld brackets.

2.2 SHROUD WELD CRACK LEAKAGE

The tie-rod assemblies are installed with a cold preload to ensure that no vertical separation of any or all cracked horizontal welds will occur during normal operations. Vertical separation, if sufficiently large, could compromise fuel geometry and control rod insertion. For NMP1, a maximum vertical separation of 13.3 inches is required for the top guide to clear the top of the fuel channels. With the repair, the licensee stated that the preload on the tie-rods will not allow vertical separation of failed welds during normal operations. The staff notes that, with or without the repair, the estimated vertical separation during normal operations will not affect the fuel geometry, and therefore, control rod insertion is not precluded. However, a small leakage path could exist due to existing through-wall shroud weld cracks. The licensee conservatively modeled the crack to provide a 0.001 inch leakage path per weld. The leakage through the postulated shroud cracks was determined to be approximately 10 gpm for cracks above the core plate, and 20 gpm for cracks below the core plate. The total leakage from all welds, H1 through H8, having 360° through-wall cracks was approximately 120 gpm. Although shroud crack leakage is unlikely due to the preload on the tie-rod, the licensee concluded that there are no consequences associated with the repair installed based on these small leakages during normal operations. The staff acknowledges that the total leakage is insignificant and will not affect the performance of the ECCS.

2.3 DOWNCOMER FLOW CHARACTERISTICS

The licensee analyzed the available flow area in the downcomer with the 4 tie-rod assemblies installed. The staff reviewed downcomer flow calculations for the upper and lower annulus area which accounted for the core spray piping, the upper support and spring, and the lower spring and C-spring. The licensee's calculations demonstrated that the installation of the tie-rod assemblies will decrease the available downcomer flow area by 5.3 percent in the upper annulus region and 3.3 percent in the lower annulus region. Due to the small diameter of the tie-rods, the decrease in available flow area in the middle region of the annulus was approximately 0.4 percent. Based on the licensee's analysis, the staff concluded that the installation of the tie-rod assemblies will not have a significant impact on the downcomer flow characteristics. Although the licensee did not provide the corresponding pressure drop to the decrease in downcomer flow area, the staff concluded that the pressure drop is insignificant based on other reviews of similar core shroud repairs. Therefore, the staff agrees with the licensee that the installation of the tie-rod assemblies should not affect the recirculation flow of the reactor.

2.4 POTENTIAL LATERAL DISPLACEMENT OF THE SHROUD

The licensee also evaluated the maximum lateral displacement of the shroud at the core support plate and upper guide plate under normal operations and load combinations such as design basis earthquake (DBE), main steam line break (MSLB), and recirculation line break (RLB). Lateral displacement of the shroud could damage core spray lines and could produce an opening in the shroud, inducing shroud bypass leakage and complicating recovery. Lateral seismic restraints have been included in the proposed design which will limit the lateral displacement of the shroud to 0.75 inches for normal and worst case accident scenarios. This lateral displacement is less than the 1.5 inch thickness of the shroud, and accordingly, the separated portions of the shroud would remain overlapped during worst case conditions. Therefore, the staff has concluded that the maximum lateral displacement of the core shroud would not result in significant leakage from the core to the downcomer region following an accident scenario.

The staff also reviewed the licensee's RLB blowdown load calculations and their affect on the potential for lateral displacement of the shroud. The licensee calculated the RLB break flow with the TRACG code based on low temperature fluid conditions. The calculated break flow was then applied to a two-dimensional potential flow theory model. Previously, the staff has not accepted loads calculated by the potential flow theory based on the lack of information to benchmark the theory and the utilization of a non-conservative assumption about the jet pumps. Since NMP1 is a non-jet pump plant, the staff's second concern does not apply. NMP1's sister plant, Oyster Creek, calculated its RLB blowdown loads using the Computational Fluid Dynamics (CFD) code COMPACT 3-D, which is capable of solving the Navier-Stokes equations in three dimensions. Comparison of Oyster Creek's and NMP1's calculated blowdown loads and input parameters established that NMP1's results are consistent with Oyster Creek's calculations. Additionally, a scoping calculation using the potential flow model was performed by the staff that included flow area blockages and head losses due to the tie-rod assemblies. This calculation provided loads comparable to Oyster Creek and NMP1.

By letter dated March 14, 1995, NMPC provided the staff with General Electric (GE) Nuclear Energy's TRACG asymmetric load calculation for NMP1. The TRACG calculation was performed with and without the tie-rods installed in order to provide validation of the potential flow methodology used. The TRACG results are more exact representations of the flow, pressures, and forces due to the RLB. The licensee compared the TRACG results without the tie-rods installed to their original potential flow model results. The comparison demonstrated that the potential flow calculation provided higher loads for nearly all elevations. This result was obtained by using the maximum break flow observed in TRACG model as the steady state break flow in the potential flow model. Further analysis of the referenced TRACG model revealed that several improvements to the potential flow model, such as increased break flow with lower feedwater temperature, increased recirculation suction nozzle internal diameter to correspond with plant as-built information, narrowed annulus area near the shroud head, and adjustment of the static pressure near the suction nozzle, could be made. The licensee made the above changes to their potential flow model and calculated the additional force due to the four tie-rods. The staff has reviewed the new potential flow model blowdown loads and concluded that they are conservative. Potential lateral displacement of the shroud following an RBL with the new blowdown loads is still limited to 0.75 inches by the mechanical stops. Therefore, the staff concluded that NMP1's RLB blowdown loads are acceptable.

On March 7, 1995, the licensee informed the staff that one tie-rod assembly was installed at the wrong location, i.e. 166° instead of 170°. The staff evaluated the affect of the different location with regards to bypass leakage and potential horizontal shroud displacement. Since the same size bolt holes were machined into the shroud head flange and support cone at the incorrect location, the total bypass leakage should remain the same. Furthermore, the 4° differential does not affect the potential lateral loads and horizontal shroud displacement significantly. Therefore, the staff concluded that the installation error of the one tie-rod assembly will not affect the systems aspects of the repair.

2.5 POTENTIAL VERTICAL SEPARATION OF THE SHROUD

The licensee evaluated the maximum vertical separation of the shroud assuming 360° through-wall cracks at H1 through H6B during a main steam line break (MSLB) and a MSLB plus a seismic event. These postulated events would result in a large upward load on the shroud which could impact the ability of the control rods to insert and the ability of the core spray system to perform its safety function. As stated above, a maximum vertical separation of 13.3 inches is required for the top guide to clear the top of the fuel channels. In the September 26, 1994 letter, the licensee calculated that the maximum vertical separation would be 12.1 inches during a MSLB, assuming 360° through-wall weld failure of the H3 weld location without the repair installed. With the tie-rod assemblies installed and the mislocation of one tie-rod by 4°, the maximum vertical separation is limited to 0.65 inches during the MSLB plus seismic event and significantly lower for a MSLB. This separation is limited by the tie-rods and should not impact the core spray system. The staff acknowledges that the ECCS performance and control rod insertion should not be impacted by this momentary vertical separation. Therefore, based on this assessment, the staff concluded that postulated separation during a MSLB combined with a seismic event would not preclude any systems from performing their safety functions.

3.0 CONCLUSION

The staff has evaluated the licensee's safety evaluation of the consequences of the proposed core shroud repair. The staff has found that the proposed repair should not impact the ability to insert control rods, and the performance of the ECCS, particularly the core spray system. The staff concluded that the proposed repair does not pose adverse consequences to plant safety, and therefore, plant operation is acceptable with the proposed core shroud repair installed.

Principal Contributor: K. Kavanagh
Dated: 3/15/95