ENCLOSURE 1

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REPORTS MPM-USE-129215 AND MPM-USE-293216

ON UPPER-SHELF ENERGY EQUIVALENT MARGINS ANALYSIS

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION UNIT NO. 1

DOCKET NO. 50-220

1.0 INTRODUCTION

By letters dated December 17, 1992, and February 26, 1993, respectively, Niagara Mohawk Power Corporation (NMPC or the licensee) submitted reports entitled, "Elastic-Plastic Fracture Mechanics Assessment of Nine Mile Point Unit 1 Beltline Plates for Service Level A and B Loadings" (Ref.1) and "Elastic-Plastic Fracture Mechanics Assessment of Nine Mile Point Unit 1 Beltline Plates for Service Level C and D Loadings," (Ref.2) for NRC staff review and approval. By letter dated September 8, 1993 (Ref.3), NMPC responded to the NRC staff's request for additional information. These reports were intended to demonstrate through fracture mechanics analysis that there exist margins of safety against fracture equivalent to those required by Appendix G of American Society of Mechanical Engineers Boiler and Pressure Vessel (ASME) Code, Section III, in the event that Nine Mile Point Nuclear Station Unit No. 1 (NMP-1) vessel beltline plates upper-shelf energy (USE) values fall below the 50 ft-lb screening criterion.

2.0 EVALUATION

The licensee followed the procedures and criteria developed by the ASME Section XI Working Group on Flaw Evaluation, which was released as ASME Code Case N-512 (Ref.4) on February 12, 1993. According to the ASME Code, Section XI, criteria for Level A and B conditions (which are the same as those in ASME Code Case N-512), the licensee assumed quarter-thickness semielliptical surface flaws with an aspect ratio of 6:1 oriented in the circumferential and axial directions. The applied J value due to a pressure of 1.15 times the accumulation pressure was calculated and added to the J value that corresponds to a thermal gradient loading due to a cooldown ramp of 100°F/hour. The combined J values ($J_{0.1\ APP}$) reported by the licensee for the circumferential and axial flaws at 0.1- inch crack extension are 70 in.-lb/in.^{2} for the circumferential and 210 in.-lb/in.^{2} for the axial. Our contractor, Oak Ridge National Laboratory (ORNL), indicates in the technical evaluation report (TER) (Ref.5) that, after including K_{Ires} of 6.6 ksi(in.)$^{1/2}$ due to clad residual stresses in the applied J calculation, the corresponding $J_{0.1\ APP_2}$ values are 90 in.-lb/in.^{2} for the circumferential flaw and 248 in.-lb/in.^{2} for the axial flaw.

As to the toughness property, $J_{0.1\ MAT}$, of the A302B plate, the licensee presented a unique engineering approach of calculating $J_{0.1\ MAT}$ based on J_{IC} and ΔJ ($J_{0.1\ MAT} = J_{IC} + \Delta J$), where both J_{IC} and ΔJ are functions of the USE. So far, only two other J-R models are available for predicting toughness of the A302B plate material: the Boiling Water Reactor Owners Group (BWROG) model (Ref.6) and the model described in a NRC memorandum (Ref.7). The NRC staff compared in Table 1 $J_{0.1\ MAT}$ values from the three J-R models for A302B plates and found the current J-R model presented by NMP-1 is not acceptable because it is least conservative among the three models for USE values below 45 ft-lb. However, based on the fact that the $J_{0.1\ APP}$ value of 248 in.-lb/in.^{2} (by ORNL) is smaller than the $J_{0.1\ MAT}$ of 256 in.-lb/in.^{2} (by method in Ref. 7) at the end-of-life (EOL) USE of 40 ft-lb, the NRC staff determines that the first criterion, which requires $J_{0.1\ APP} < J_{0.1\ MAT}$, was satisfied. This conclusion is consistent with ORNL's. ORNL used a more rigorous, but more complex procedure to draw a similar conclusion.

Further, ORNL showed in Figure 14 of the TER that under the combined loads of pressure of 1.25 times the accumulation pressure and the thermal gradient load, the slope of the applied J curve is smaller than the slope of the material J curve at the intersection. Consequently, the second criterion, which requires $(dJ/da)_{APP} < (dJ/da)_{MAT}$, is satisfied for Level A and B conditions.

According to the criteria of Code Case N-512 for flaws under Level C and D conditions, the licensee assumed semielliptical surface flaws with an aspect ratio of 6:1 oriented in the circumferential and axial directions, with depths up to one-tenth of the sum of the base metal and the clad thicknesses, $(T_b + T_{cl})/10$. The maximum depth, in accordance with ASME Code Case N-512, should be $T_b/10 + T_{cl}$ instead. ORNL employed the FAVOR code (Ref.8), and performed independent Level C and D equivalent margins analyses by using the correct maximum flaw depth and the same transients in the reports: the 250°F/7.5 min. blowdown for Level C loading and the steam line break for Level D loading. Results summarized in Figures 18 and 19 of the TER indicate that the minimum permissible EOL USE values are much smaller than 40 ft-lb; and therefore, Level A and B conditions are controlling. ORNL did not perform similar analyses on smaller flaws because it was noted from other Level C and D analyses that within the range of flaw sizes specified by Code Case N-512, the maximum value of K_I tends to be monotonically increasing.

The subject reports did not evaluate weld material, and a later report submitted by letter dated March 19, 1993, entitled, "Generic Letter 92-01, Revision 1, Reactor Vessel Structural Integrity, Upper Shelf Energy Estimates for Beltline Welds," failed to address properly the issue of lack of initial USE values for NMP-1 vessel beltline welds. This report consists of two parts: first, a method (the yield strength model) for predicting the USE decrease based on the increase of yield strength due to irradiation; and second, an initial USE estimation method based on USE data from surveillance weld and a two-sigma scatter of USE from a reduced data set of the Power Reactor Embrittlement Database (PR-EDB). The NRC staff did not accept this analysis because the weld wire heat number of the surveillance weld is

different from those of the beltline welds and the surveillance weld is not considered representative of any of the beltline welds. However, by using an initial USE of 75 ft-lb (Ref.9), which was developed by the NRC staff from all PWR and BWR surveillance welds fabricated by Combustion Engineering with Arcos B-5 and Linde 0091, 124, and 1092 flux, the NRC staff has determined that all EOL USE values of NMP-1 welds exceed 50 ft-lb and no further action is required.

3.0 CONCLUSION

The NRC staff has completed its review of reports MPM-USE-129215 and MPM-USE-293216 and based on the NRC staff's own review and the TER by ORNL, the NRC staff concludes that the NMP-1 reactor pressure vessel plates have adequate margins of safety against fracture until the EOL (25 EFPY) for all Level conditions (A, B, C, and D) and meet the criteria in the ASME Section XI Code Case N-512. This conclusion applies to weld material as well because based on a generic initial USE developed by the NRC staff for Combustion Engineering fabricated welds, the welds were determined to be not limiting. The NRC staff further concludes that the NMP-1 reactor pressure vessel plates and weld material satisfy the requirements of 10 CFR Part 50, Appendix G, Section IV.A.1. in that the USE values for these plates and welds will provide margins of safety against fracture equivalent to those required by Appendix G of Section III of the ASME Code and are, therefore, acceptable.

4.0 REFERENCES

1. MPM-USE-129215, "Elastic-Plastic Fracture Mechanics Assessment of Nine Mile Point Unit 1 Beltline Plates for Service Level A and B Loadings," MPM Research & Consulting, December 16, 1992 (first revision); February 19, 1993 (second revision with the part related to plate 533B removed).

2. MPM-USE-293216, "Elastic-Plastic Fracture Mechanics Assessment of Nine Mile Point Unit 1 Beltline Plates for Service Level C and D Loadings," MPM Research & Consulting, February 22, 1993.

3. Responses to RAI on reports MPM-USE-129215 and MPM-USE-293216P, Niagara Mohawk Power Corporation, September 8, 1993.

4. Code Case N-512, "Assessment of Reactor Vessels with Low Upper Shelf Charpy Impact Energy Levels, Section XI, Division 1," ASME Boiler and Pressure Vessel Code, February 12, 1993.

5. J. G. Merkle and D. K. M. Shum, "Technical Evaluation Report (TER) Review of NMPC Project 03-9425 Reports, 'Elastic-Plastic Fracture Mechanics Assessment of Nine Mile Point Unit 1 Beltline Plates for Service Level A and B Loading (MPM-USE-129215) and Service Level C and D Loading (MPM-USE-293216)'" Oak Ridge National Laboratory, December 21, 1993.

6. NEDO-32205, "10CFR50 Appendix G Equivalent Margin Analysis for Low Upper Shelf Energy in BWR/2 Through BWR/6 Vessels," Licensing Topical Report for the BWR Owners Group, GE Nuclear Energy, April 1993.

7. Memorandum, A.L. Hiser and S.N.M. Malik of USNRC to K.R. Wichman, USNRC, "J-R Curves for Low Toughness A302B Plate," USNRC, September 9, 1993.

8. T.L. Dickson, "FAVOR: A New Fracture Mechanics Code for Reactor Pressure Vessels Subjected to Pressurized Thermal Shock," pp. 3-9 in Pressure Vessel Integrity - 1993, PVP Vol. 250, ASME, 1993.

9. Amendment No. 158, S. Bloom of USNRC to T.L. Patterson, Omaha Public Power District, "Fort Calhoun Station, Unit No. 1 - Amendment No. 158 to Facility Operating License No. DPR-40," December 3, 1993.

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TABLE 1

Comparison of $J_{0.1}$ for low toughness A302B plates

T= 525°F

EOL USE ft-lb	$J_{0.1}$ (NMP-1) in.-lb/in.^{2}	$J_{0.1}$ (BWROG) in.-lb/in.^{2}	$J_{0.1}$* (draft Regulatory Guide) in.-lb/in.^{2}
35	236	195	216
40	298	222	256
45	314	249	297
50	329	276	339

* The safety factor (SF) of 0.749 used for high toughness plates has been applied