ENCLOSURE

SAFETY EVALUATION
OFFICE OF NUCLEAR REACTOR REGULATION
CONTAINMENT SYSTEMS AND SEVERE ACCIDENT BRANCH
DIVISION OF SYSTEMS SAFETY AND ANALYSIS
RELATED TO THE PROPOSED DEFERMENT OF TORUS MODIFICATIONS
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT NUCLEAR STATION UNIT NO. 1
DOCKET NO. 50-220

1.0 INTRODUCTION

The Nine Mile Point Unit No. 1 (NMP1) containment torus shell was originally designed and constructed of uncoated carbon steel plate which has been subject to corrosion from the suppression pool water. The original design of the torus had included an allowance for shell corrosion and the NMP1 licensee has been monitoring the torus shell material thickness for thinning due to this corrosion since 1975. The critical corrosion takes place on the inner surface of the torus shell below the suppression pool water level. The original design stress analysis for the torus shell had determined a minimum required shell thickness of 0.40 inches and the torus shell had been constructed and certified to a minimum shell thickness of 0.46 inches which had included a corrosion allowance of approximately 1/16 inch. That torus shell thickness for construction was based on an analysis which included some of the containment loads such as the pressure and temperature response to a LOCA, seismic capability, and deadweight. A corrosion allowance was included.

The original stress analysis for construction of the torus shell determined the minimum required wall thickness of 0.40 inches assuming the design basis loads within the suppression pool which were known at that time. However, the original containment design did not include hydrodynamic loads from a Loss-Of-Coolant Accident (LOCA) or a Safety/Relief valve (SRV) actuation. These loads were considered afterwards as the result of generic requirements imposed by the NRC staff (Reference 1) on all operating Boiling Water Reactors (BWRs). As a result of the generic requirement to evaluate hydrodynamic loads (Reference 1), the licensee for each BWR with a Mark I containment submitted to the staff a Plant Unique Analysis Report (PUAR) which contained the revised plant specific stress analysis for the torus shell and included an evaluation for LOCA and SRV hydrodynamic loads in addition to the pressure and temperature response and seismic loads. These additional loads then became part of the containment licensing basis and a new minimum shell thickness for compliance with the ASME code was calculated. The NMP1 PUAR (Reference 2) demonstrated that sufficient margin existed in the torus shell to accommodate the additional hydrodynamic loads. The revised stress analysis in the PUAR determined a new minimum shell thickness of 0.447 inches.

Torus shell corrosion had been previously documented by the NMP1 licensee (Reference 3) and reviewed by the staff in a previous SER (Reference 4). However, NMP1 has been experiencing a corrosion process at an approximate rate of 0.00126 inches per year as documented in the licensee's letter of May 14, 1991 (Reference 3). At that corrosion rate, the torus wall would reach the minimum wall thickness before the plant had reached the 1994 outage,

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assuming the plant design basis loads had remained unchanged. The licensee had proposed several solutions to the problem of the torus wall thinning which included a physical modification to the torus and possible reanalysis of the torus load forcing function. The latter would be an effort to reduce the design basis load within the torus shell during a LOCA and in effect would result in a smaller required torus shell minimum wall thickness.

In an August 25, 1992 SER (Reference 4), the NRC staff approved a proposal by Niagara Mohawk Power Corporation, the Nine Mile Point Unit 1 licensee, to reduce condensation oscillation (CO) loads below that which had been approved by the staff for the Nine Mile Point Unit 1 PUAR (Reference 2). That submittal proposed to adjust the methodology for calculation of the hydrodynamic forcing function to include a wall pressure reduction factor which was intended to remove some additional conservatism inherent in the Load Definition Report (LDR) method (Reference 5). This was an attempt by the licensee to reduce the design basis loads imposed upon the containment, thereby reducing the required minimum shell thickness. However, in that SER (Reference 4) the staff misunderstood the licensee's submittal to have requested the use of wall pressure reduction factors to be applied with the summing methodology as described in the Mark I LDR (Reference 5). This application of the strict use of the LDR summing methodology along with the use of wall pressure reduction factors was never intended by the licensee.

The summing methodology referred to above is a technique used to sum the individual wall pressure amplitudes at each harmonic. For the evaluation of the hydrodynamic loads on a Mark I torus, General Electric choose to describe the forcing function, in this case the CO load, with a response spectrum. The response spectrum for this phenomenon was shown as a plot of the maximum wall pressure amplitude as a function of frequency. The summing technique is used to combine the calculated wall pressure amplitudes at each harmonic of interest which is essentially a numerical integration used to calculate the system response. The two summing methods discussed here are the absolute sum (ABSS) of all the harmonics and a modified combination of the square root of the sum of the squares of all the harmonics except the four peak amplitudes which are combined in an absolute fashion (referred to here simply as ABSS/SRSS). If the ABSS method is used with the wall pressure reduction factors in lieu of the ABSS/SRSS summing method, no significant reduction in torus shell stress will be achieved and therefore no advantage is gained by the use of the wall pressure reduction factors.

The licensee's submittal of May 14, 1991 (Reference 3), had proposed the use of wall pressure reduction factors for the CO load for a specific Event Combination. The Event Combination is a specific sequence of postulated events and plant response (LOCA, SRV discharge, Chugging, etc.) assumed to occur. The licensee proposed to maintain the ABSS/SRSS method for combining the stresses with the application of wall pressure reduction factors. This summing technique had been previously approved by the staff in its safety evaluation report on the NMP1 PUAR (Reference 9). The staff had interpreted the NMP1 May 14, 1991 submittal to have proposed replacing the ABSS/SRSS method with the LDR method (which is ABSS only).

The purpose of the wall pressure reduction factors was to account for specific differences in geometry between NMP1 and the Full Scale Test Facility (FSTF) which was used to define the CO load. The specific difference in geometry between NMP1 and other BWRs is the 4-8-4 downcomer arrangement. At NMP1, the torus contains alternating groups of four (4) downcomers and eight (8) downcomers per bay as opposed to other Mark I containments which contain eight (8) downcomers in every torus bay. The NMP1 submittal then proceeded to establish the technical basis for the wall pressure reduction factors.

The staff approval of the wall pressure reduction factors alone without the concurrent use of the ABSS/SRSS method would not have yielded sufficient reduction in the calculated membrane stress within the torus shell which the licensee was trying to achieve. The NMP1 licensee clarified their position to the staff on the use of ABSS/SRSS method concurrent with wall pressure reduction factors in a letter dated November 23, 1992 (Reference 6). The following staff evaluation accepts the use of the ABSS/SRSS method concurrent with the use of wall pressure reduction factors.

2.0 EVALUATION

In the NMP1 submittal of May 14, 1991, the NMP1 licensee attempted to demonstrate the acceptability of their methodology for calculation of wall pressure reduction factors to be applied to the calculated CO wall pressures of Event Combination 20 (which is DBA LOCA pressure, OBE seismic, deadweight and DBA CO loads). The licensee's justification for the use of these reduction factors to adjust the LDR pressure amplitudes is principally based on the observation that the FSTF, which is the basis for the LDR method, is not representative of the Nine Mile Point Unit 1 torus. The principal differences, as described above, are the NMP1 4-8-4 downcomer arrangement which is not reflected in the FSTF pattern of 8-8 downcomer arrangement and the rigid end caps of the FSTF which would be more representative of a 8-8 downcomer torus arrangement. The NMP1 licensee concluded that the 8-8 downcomer arrangement for FSTF as opposed to a 4-8-4 arrangement for NMP1 causes an overestimation of CO wall pressures for NMP1. The NMP1 submittal attempted to quantify the overestimation in the calculational procedure used in the LDR through the use of wall pressure reduction factors.

These reduction factors would be used to adjust the LDR wall pressure amplitudes to account for the reduced number of downcomers in the NMP1 suppression pool which would equate to a smaller number of energy sources in the pool. Since the torus bays communicate easily with one another, accounting for a 4-8-4 downcomer arrangement will produce a substantial decrease in the CO contribution of the total load on the torus shell within all bays of the torus. In the August 25, 1992 SER, the staff and Brookhaven National Laboratory (BNL) found the NMP1 proposal for the use of wall pressure reduction factors to be acceptable when the LDR method for summing of shell stresses is used, that being ABSS only.

The NMP1 licensee proposed in their submittal (Reference 3) using both the ABSS/SRSS method for combining the torus shell stresses at each harmonic and using a wall pressure reduction factor for CO phase only to account for geometric difference in the NMP1 torus (4-8-4 downcomer arrangement). Since

the wall pressure reduction factors further refine the LDR calculational method and remove margin from that method, the staff requested BNL to perform confirmatory calculations and examine the sensitivity of the total shell stress to this change in methodology. The staff's intent was to independently verify the wall pressure reduction that would be expected in a torus which contains alternating bays of 8 and 4 downcomers per bay, such as the NMP1 arrangement.

The calculational method decided upon by the staff and BNL, the Method of Images, was believed to be suited for this application and had been used by the General Electric Company in the DFFR (Reference 7) for the study of SRV generated hydrodynamic loads in a Mark II type containment. The calculation performed by BNL was intended to account for the geometric differences between the FSTF and the NMP1 torus and test geometric sensitivity. The description of the calculation and specific results obtained are presented in the attached report from BNL.

Comparison of the BNL and NMP1 results indicate good agreement between the two independent calculations and, in fact, the greatest difference in results is approximately 6%. The staff and BNL consider this difference between calculations to be minor and did not expect to achieve such close agreement. The staff and BNL attempted to demonstrate the varying pressure amplitude evaluated from the center of the 8 downcomer bay to the center of the 4 downcomer bay. This calculation verifies the NMP1 position that there is a substantial reduction in load on the torus shell when the 4-8-4 downcomer arrangement is considered. Calculation of the pressure amplitude distribution by BNL was intended reproduce the general trend in the wall pressure reduction which is graphically displayed in the BNL report in Figure 2. Figure 2 shows the relativity good agreement between the two methods and has predicted the trend between vent and nonvent bays for both the correlated and uncorrelated CO sources. Based on this relatively good agreement between both calculations, the staff approves the use of the calculational method for predicting the CO wall pressure reduction factors for NMP1 on Event Combination 20.

The analysis of the hydrodynamic loads is done for specific Event Combinations. These Event Combinations are based on different postulated pipe breaks within the containment or SRV actuation with varying time duration. For the evaluation presented to the staff by the NMP1 licensee in Reference 3, the Event Combination discussed was for Event Combination 20 which is the DBA LOCA pressure load, DBA CO load plus other loads such as the OBE and deadweight. This Event Combination yields the highest shell stress. Of the total stress produced in the shell by this Event Combination, the CO load contributes approximately 30% to the total stress. Since the CO load comprises a portion of the total load, a reduction of CO load (based on the calculated wall pressure reduction factors) of 20% to 40% for uncorrelated sources does not yield equal reductions in the total shell stress. The reduction in total membrane stress in the torus shell is approximately 10% as a result of the advantage gained by the use of wall pressure reduction factors.

Other Event Combinations such as Event 14 (based on an intermediate break size

LOCA and SRV discharge plus other loads such as seismic and deadweight) yield the next highest shell stresses involving CO loads. These were also evaluated by the NMP1 licensee and reviewed by the staff. The contribution from the CO load in Event Combination 14 is approximately 6.1% and the licensee did not propose to utilize wall pressure reduction factors for this event. Using the methodology proposed by the licensee, Event Combination 20 does not result in a drastic reduction in calculated shell stress. However, the staff has concluded sufficient margin exists between calculated shell stress and allowable stress based on the calculations performed by the NMP1 licensee and the independent calculation made by BNL.

The revised wall pressures using the reduction factors were then used by the licensee to calculate the torus shell stresses. These were submitted in the May 14, 1991 NMP1 letter (Reference 3). That structural evaluation had been previously reviewed by the staff in the August 25, 1992 evaluation (Reference 4). In that SER, an evaluation was made of the NMP1 structural analysis based on the revised CO load resulting from the application of the wall pressure reduction factors. That evaluation concluded that the revised CO loads result in a membrane stress, assuming an original shell thickness of 0.46 inch at the critical shell location, of 15,452 psi, reduced from a stress of 16,025 psi based on original CO load. According to the ASME Section III Code (1977) the allowable stress of the shell material used is 16,500 psi. With the reduced CO loads, this maximum allowable stress would not be reached until the torus shell thickness is reduced to less than 0.431 inch. The staff has reviewed the NMP1 analysis and finds it to be acceptable. Based on the observed corrosion rate and an expectation that the thinnest panels of the torus wall may be reduced to an average thickness of 0.447 inch in 1994, the licensee has determined that the maximum allowable stress value would not be reached until approximately the year 2007.

The ring girder was evaluated by the staff to determine the manner in which NMP1 would apply the CO loads. Since a ring girder is at every junction between an 8 downcomer bay and a 4 downcomer bay, an asymmetrical condition, the staff questioned how the CO load would be applied to the ring girder for calculation of the structural response. The method used in the NMP1 PUAR assumed a half bay structural model on each side of the ring girder which would average CO pressures for each adjacent bay. The adjacent bays have CO pressures which may differ by as much as 20%. The concern is that the ring girder response may not be modelled correctly by half bay average pressures since a pressure gradient would exist in reality across the ring girder. To resolve this concern, the licensee agreed in their November 30, 1993 letter (Reference 8) to use the higher non-vent bay loads for evaluation of the ring girder stresses within the region adjacent to the miter joint. The staff finds this approach acceptable.

As stated in the staff's previous evaluation (Reference 4), the staff believes that it is appropriate for the NMP1 licensee to continue to monitor the corrosion rate of the torus shell to assure that any reduction in the shell thickness due to corrosion will not result in stresses greater than the code allowable in future operation. Therefore, the licensee is requested to maintain the torus shell monitoring program as follows:

1. UT thickness measurements of all torus bays shall be performed as described in the staff's pervious SER (Reference 4) in order to confirm that the assumed maximum average corrosion rate of 0.00126 inch per year is conservative. The six previously identified torus bays having the minimum wall thickness continue to be monitored every 6 months and are the only bays requiring periodic monitoring.

2. Unless additional bays requiring periodic monitoring are identified, and more frequent monitoring is required as determined from the results of item 1 above, the current program of UT thickness measurements at 6 month frequencies for the six torus bays shall be continued. At these bays, a standard corrosion sample coupon with the same steel material as that of the torus shell shall be installed at the waterline in the suppression pool with approximately one-half above and one-half below the waterline. The corrosion rate obtained from these coupons shall be compared (once per refueling outage) to that from the UT measurements of the shell and the most conservative corrosion rate shall be used to make future corrosion rate determinations.

3. Item 1 above shall be repeated at a frequency not less than that of containment inspections pursuant to 10 CFR Part 50, Appendix J, before performing the periodic Type A test if a corrosion rate of greater than 0.00126 inch per year is determined. The monitoring results shall be reviewed to assure that the minimum wall thickness requirements (0.431 inch) will not be exceeded during planned subsequent operation.

4. If the corrosion rate does not exceed 0.00126 inch per year and therefore reinspection in accordance with item 3 above is not required, a reinspection in accordance with item 1 above shall be repeated after approximately 10 years.

The results of the above monitoring program shall be submitted to the NRC within approximately 60 days after completion of each inspection.

3. CONCLUSION

On the basis of the staff's reevaluation of the information provided by the NMP1 licensee, the staff concurs with the licensee's conclusion that as a result of the reduction in CO loads, the NMP1 torus currently meets the ASME code requirements. With the implementation of the UT monitoring described above, the staff has determined that NMP1 has provided sufficient justification for concluding that the torus will continue to meet the ASME code provided that the average minimum wall thickness of the torus shell is not reduced to less than 0.431 inch.

4. REFERENCES

1. U.S. NRC, "Safety Evaluation Report, Mark I Long-Term Program, Resolution of Generic Technical Activity A-7," NUREG-0661, dated July 1980.

2. Teledyne Engineering Services, "Mark I Containment Program, Plant-Unique Analysis Report of the Torus Suppression Chamber for Nine Mile Point Nuclear Generating Station, Unit 1," TES TR-5320-1, Revision 1, dated September 21, 1984.

3. Niagara Mohawk Power Corporation, letter NMP1L, 0583, from C. D. Terry to U.S. NRC, dated May 14, 1991.

4. U.S. NRC, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Proposed Deferment of Torus Modifications, Niagara Mohawk Power Corporation, Nine Mile Point Nuclear Station, Unit No. 1, Docket Number 50-220," dated August 25, 1992.

5. General Electric Company, "Mark I Containment Program Load Definition Report," GE Topical Report, NEDO-21888, Revision 2, November 1981.

6. Niagara Mohawk Power Corporation, letter NMP1L 0716, from C.D. Terry to U.S. NRC, dated November 23, 1992.

7. General Electric Company, "Mark II Containment Dynamic Forcing Function Information Report," GE Topical Report, NEDO-21061, Revision 3, June 1978.

8. Niagara Mohawk Power Corporation, letter NMP1L 0791, from C.D. Terry to U.S. NRC, dated November 30, 1993.

9. U.S. NRC, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Mark I Containment Long-term Program Pool Dynamic Loads Review, Niagara Mohawk Power Corporation, Docket Number 50-220, dated January 22, 1985.