ENCLOSURE

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RESPONSES TO NRC BULLETIN 88-08

AND SUPPLEMENTS "THERMAL STRESSES IN PIPING

CONNECTED TO REACTOR COOLANT SYSTEMS"

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION UNIT NO. 1

DOCKET NO. 50-220

1.0 BACKGROUND

By letter dated September 29, 1988, Niagara Mohawk Power Corporation (NMPC) responded to NRC Bulletin 88-08, "Thermal Stresses In Piping Connected To Reactor Coolant Systems," and Supplements 1 and 2. That response identified three systems (Reactor Head Spray Line, Feedwater System at the reactor feedwater nozzles and the Reactor Water Cleanup System mixing tee, and Emergency Cooling System condensate return lines) as potentially susceptible to the thermal cycling fatigue phenomena described in the bulletin. The September 29, 1988, submittal also noted that due to excessive seat leakage of the 39-05 and 39-06 condensate return line isolation valves, a 10 CFR Part 50, Appendix J, schedular exemption had been approved by the NRC that allowed deferral of modifications to these valves until the next refueling outage. NMPC committed to reevaluate the condensate return line piping after completion of required modifications.

By letter dated December 16, 1991, NMPC supplemented its September 29, 1988, response and stated it had instituted modifications and operational changes to the Reactor Head Spray Line and the Feedwater System in accordance with Option 1 of Action 3 of NRC Bulletin 88-08. NMPC's December 16, 1991, submittal stated that the Emergency Cooling System condensate return line had been examined and that no evidence of cracks or rejectable indications had been found. NMPC also requested and was granted an extension, until the 1994 refueling outage (now scheduled for 1995), to the previously-approved schedular exemption for the condensate return line isolation valves. Seat leakage of these isolation valves could impact the unisolable sections of the Emergency Cooling System as described in the bulletin. Therefore, ABB Impell Combustion Engineering (CE), under contract to NMPC, performed an evaluation of these sections using measured leakage values and industry-based data on turbulence penetration, and concluded that these sections were not subjected to temperature distributions which would result in unacceptable thermal

stresses during normal plant operation. This evaluation was reported in "Evaluation of the Emergency Condenser Return Line at NMP1 With Regard to Thermal Stratification, Cycling and Striping, and NRC Bulletin 88-08," ABB Impell Report #Misc-MPS-ER-032, Revision 0, December 1991.

During April 1992, NMPC noted a gradual increase in drywell unidentified leakage. During a forced outage which began on May 1, 1992, NMPC determined this leakage was the result of a through wall crack in an Emergency Cooling System condensate return line valve body. This crack and other partial penetration cracks were determined to be due to the thermal fatigue phenomena identified in NRC Bulletin 88-08.

This thermal fatigue cracking phenomena was discussed in a May 18, 1992, meeting (meeting minutes issued May 26, 1992) during which NMPC proposed repairs which are not authorized by the ASME Code. After evaluation of NMPC's proposals, the NRC staff informed NMPC by telephone on May 19, 1992, that due to several uncertainties in NMPC's analyses, the NRC staff would not approve the non-Code repairs and stated that the Emergency Cooling System should be repaired in accordance with ASME Code requirements. Such repairs were made and the plant subsequently resumed operation on August 2, 1992.

By letter dated July 9, 1992, NMPC requested a revision to the above noted Appendix J schedular exemption. The requested revision was issued on July 24, 1992. This revision included deletion of valves 39-05 and 39-06 from the exemption. These valves were deleted from the exemption since they had been refurbished during the forced outage to ensure that summation of their leakage with leakage from other containment penetrations would meet the leakage requirements of 10 CFR Part 50, Appendix J.

By letter dated July 20, 1992, NMPC provided information which modified its December 16, 1991, response to NRC Bulletin 88-08. The July 20, 1992, submittal provided an evaluation of the thermal fatigue cracks discovered in the Emergency Cooling System valve bodies and provided a commitment to implement a temperature monitoring program for the unisolable portions of the Emergency Cooling System in accordance with Option 2 of Action 3 of NRC Bulletin 88-08. NMPC also indicated in this submittal that data obtained from the temperature monitoring program would be used to determine the apparent causes of thermal cycling and ultimately provide the basis for modifications and/or operational changes to eliminate/control the thermal cycling. The submittal of July 20, 1992, stated that NMPC would provide the NRC details of the modification plans when they have been finalized.

2.0 EVALUATION

NMPC has instituted modifications and operational changes to resolve concerns for the Reactor Head Spray Line and the Feedwater System. Specifically, the unisolable section of the Reactor Head Spray Line was removed from service and changes were made to provide more stable control of feedwater under low flow conditions, thereby significantly reducing the number of thermal cycles

experienced in the vicinity of the Reactor Water Cleanup System mixing tee and reactor feedwater nozzles. These changes are clearly consistent with Option 1 of Action 3 of NRC Bulletin 88-08.

The CE evaluation was intended to demonstrate that the unisolable portion of the condensate return lines is not susceptible to the thermal stratification or thermal cycling phenomena described in the bulletin.

This evaluation effort consisted of three tasks: postulation of a potential leakage flow mechanism; determination of the potential for flow stratification in the unisolable section; and the evaluation of the stresses which could potentially exist due to intermittent or continuous check valve leakage.

CE determined that potential leakage could occur from the condensate return lines to the recirculation line through the isolation valve separating these lines. The current leakage flow was determined to be about 3 gpm, based on actual flow measurements in the Emergency Cooling System, and this was postulated as the maximum potential flow for the evaluation.

To evaluate the potential for flow stratification, CE invoked the results of an ongoing test program TASCS (Thermal Stratification, Cycling and Striping) sponsored by the Electric Power Research Institute (EPRI). (Reference Kim, J. H., et. al, "Thermal Stratification in Nuclear Reactor Piping System," presented at the International Conference on Nuclear Engineering (ICONE), November 1991, Japan.) CE also referred to data obtained at CE plants but did not provide nor reference this data.

CE stated that both the EPRI and the CE data indicate that the turbulence in the recirculation line appears to propagate deep into branch lines attached to the main line. This hydraulic effect is termed "turbulence penetration," and apparently can reach well past 10 branch pipe diameters when the main flow is sufficiently high. CE determined that under normal flow conditions in the main recirculation line and a leakage of 3 gpm through the isolation valve, the turbulence penetration in the unisolable sections could extend as much as 13 pipe diameters into the branch lines; on each line a check valve between the isolation valve and the recirculation line is located 7 pipe diameters from the recirculation line nozzle. CE also determined that for a leakage of 3 gpm through the check valve the leakage flow would also be turbulent, which would enhance mixing with the turbulence penetration. On this basis, and on the basis of other considerations (e.g., natural convection in the upstream piping), CE concluded that thermal stratification and stratified flow conditions could not exist in any form during power operation with high flow in the main recirculating system, and therefore no stratification, striping or thermal cycling conditions could realistically exist which would lead to crack initiation and crack propagation. However, CE also evaluated the potential stresses which might exist under assumed thermal cycling conditions, and concluded that these would be below the endurance limit of the piping material.

On the basis of this evaluation, NMPC revised its response to Action 1 to state that the condensate return lines are not susceptible to the phenomena described in the bulletin, and therefore that a response to Action 3 of the bulletin was not necessary.

The NRC staff has reviewed the CE evaluation, and has concluded that it is based on assumptions which do not conform with the available facts about the events described in the bulletin:

- The CE evaluation is based on the measured leakage rate of 3 gpm. The leakage rates mentioned in the bulletin were considerably smaller (on the order of .5 gpm). Indications are that there probably exists an optimum leakage rate (between zero and full flow) less than 3 gpm at which the potential for stratification and thermal cycling is greatest. This optimum leakage rate was not determined in the evaluation.

- The interaction process of turbulence penetration and leakage flow from an isolation valve through an intervening check valve, and its effect on potential stratification and thermal cycling, is currently being evaluated in the TASCS program. CE has assumed in its analysis that the penetration depth is constant with time. This assumption is not supported by the previously referenced paper by Kim, et. al., which indicates that the penetration may be of a cyclical nature, and may thus contribute significantly to the thermal cycling.

- The assumption that the penetration tends to mix continuously with the stratified fluid, thus creating a homogeneous fluid, contradicts actual observation. The recorded temperature data at Farley indicate that the stratification was preserved during the time when the isolation valve was leaking, with considerable cycling of the colder fluid. CE also claimed that the penetration at Farley (and Tihange) must have been very shallow, due to the bends in these lines a short distance from the connections with the recirculation line piping. There appears to be no basis for these assertions. At Farley, the cracked weld was located at 5 pipe diameters from the recirculation line, while at Tihange the nearest crack occurred about 4.5 diameters from the recirculation line. From the geometries of these lines there is no reason to suppose that the turbulence did not penetrate beyond these distances up to the respective check valves, under operating flow conditions. These cracks therefore occurred at locations and under conditions which were predicted to preclude their occurrence.

- CE attributed the cracking at Farley and Tihange due to beam-bending caused by periodic thermal cycling. The evaluation of the Farley data indicated that the cracks were caused by highly localized through-wall stresses. The stresses due to beam-bending were found to be considerably smaller.

- CE attributed the thermal cycling at Farley and Tihange to oscillating pressure differentials across the check valves due to the charging pumps.

Since these are centrifugal pumps this effect was not reflected in the measured temperature data upstream of the check valve, during leakage through the isolation valve.

- As part of the analysis, CE assumed a static opening angle for the swing check valve. This angle should have been based on fluid mechanics principles. The assumption that it is in static equilibrium was not substantiated.

Subsequent to the submittal of the CE evaluation results and the discovery of thermal fatigue cracks in Emergency Cooling system valve bodies, NMPC committed to implement a temperature monitoring program for the unisolable portions of the Emergency Cooling System. Data obtained from this monitoring program will be used to determine the apparent causes of thermal cycling and provide the basis for modifications and/or operational changes to eliminate/control the thermal cycling. NMPC's monitoring program is consistent with Option 2 of Action 3 of NRC Bulletin 88-08.

3.0 CONCLUSION

Based on our review and evaluation, we have concluded that the CE analysis does not provide the assurance requested by Action 3 of the bulletin, that the unisolable sections of the Emergency Cooling System condensate return lines will not be subjected to cyclic thermal stresses which could cause fatigue failure during the life of the plant. However, since NMPC is not now relying on the results of the CE analysis and has instituted an appropriate temperature monitoring program for the Emergency Cooling System, we have also concluded that NMPC's actions to address concerns for the Head Spray Line, Feedwater System, and Emergency Cooling System are consistent with the options provided in Action 3 of the bulletin and therefore acceptable.

Principal Contributors: M. Hartzman
D. Brinkman
J. Menning

Date: November 13, 1992

The NRC staff has completed its review of the NMPC responses to NRC Bulletin 88-08, as documented in the enclosed safety evaluation. We have concluded that the CE analysis does not provide the assurance requested by Action 3 of the bulletin, that the unisolable sections of the Emergency Cooling System condensate return lines will not be subjected to cyclic thermal stresses which could cause fatigue failure during the life of the plant. However, since NMPC is not now relying on the results of the CE analysis and has instituted an appropriate temperature monitoring program, we have also concluded that NMPC's actions to address concerns for the Head Spray Line, Feedwater System, and Emergency Cooling System are consistent with the options provided in Action 3 of the bulletin and are therefore acceptable. Consequently, we consider this action complete and TAC No. M69665 is closed. Further NRC review of the NMPC responses to NRC Bulletin 88-08, if any, will be performed by inspection or audit.

In accordance with NMPC's July 20, 1992, commitment to apprise the NRC of any Emergency Cooling System modifications and/or operational plans to eliminate/control the thermal cycling, please notify us in writing when such plans have been finalized and when any necessary modifications have been implemented.

This requirement affects one respondent and, therefore, is not subject to Office of Management and Budget review under P.L. 96-511.

Sincerely,
Original signed by:
Donald S. Brinkman, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosure:
Safety Evaluation

cc w/enclosure:
See next page

Distribution:

Docket File	CVogan
NRC & Local PDRs	OGC
PDI-1 Reading	ACRS (10)
SVarga	PDI-1 Plant File
JCalvo	CCowgill, RGN I
RACapra	JNorberg, 7/E/23
DBrinkman	MHartzman, 7/E/23
JMenning	

PDI-1:LA	PDI-1:PM	PDI-1:PM	EMEB	PDI-1:D	
CVogan	DBrinkman:smm	JMenning	JNorberg	RACapra	
11/4/92	11/4/92	11/4/92	11/10/92	11/13/92	/ /

OFFICIAL RECORD COPY
FILENAME: NM169655.LTR