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STAFF EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING AN ALTERNATIVE TO NUREG-0619

FOR INSPECTING FEEDWATER AND CONTROL ROD DRIVE RETURN LINE NOZZLES

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION, UNIT 1

DOCKET NUMBER 50-220

1.0 INTRODUCTION

In a letter dated December 29, 1980, Niagara Mohawk Power Corporation (NMPC) committed to the inspection recommendations contained in NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking," for Nine Mile Point Nuclear Station, Unit 1 (NMP1). Subsequently, in letters dated June 23 and September 12, 1994, December 15, 1995, and September 4, 1998, NMPC informed the NRC and explained its decision to revise the commitment for NMP1's feedwater (FW) and control rod drive return line (CRDRL) nozzle inspections. The revised commitment for FW nozzle inspections would be in accordance with the recommendations in the Boiling Water Reactor Owners Group (BWROG) Report GE-NE-523-A71-0594, "Alternate BWR Feedwater Nozzle Inspection Requirements," dated October 31, 1995, subject to the modifications identified in a related NRC staff safety evaluation report dated June 5, 1998. NMPC's revised commitment for CRDRL nozzle inspections would replace periodic dye penetrant testing (PT) with less frequent ultrasonic testing (UT).

In the following sections, the NRC staff discusses NMPC's initial and revised commitment to the inspection recommendations of NUREG-0619 and presents its evaluation of NMPC's revised inspection commitments.

1.1 Background

On November 13, 1980, the NRC staff issued NUREG-0619 to notify licensees of a cracking problem on the inner radius of FW and CRDRL nozzles. The NUREG provides recommendations for resolving the cracking problem and for additional inspections beyond those required by the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). The cause of the cracking was attributed to relatively cooler FW leaking past loosely fitted thermal sleeves that were installed in FW nozzles and to the thermal stratification in the slow flowing water from the CRDRL nozzle. The colder water cycling through the nozzles into the reactor pressure vessel produced thermal cracks at the hot-cold water interface on the inner FW nozzle radius and the inner CRDRL nozzle radius and the reactor pressure vessel area below the inner CRDRL nozzle radius.

Enclosure

When NUREG-0619 was issued, several UT examination techniques were being used by licensees to inspect the inner (blend) radii and bore regions of the FW and CRDRL nozzles from the exterior of the reactor pressure vessel. The technical and experimental bases were not available to define the probability of finding a given sized flaw within the inner radius, bore, or safe-end with the accuracy and repeatability required in order to rely upon a given UT technique as the primary means of inspection. Factors affecting UT examinations included complex geometry, long examination metal paths, and inherent ultrasonic beam spread, scatter, and attenuation. To assure adequate structural integrity, the NRC staff recommended in NUREG-0619 nondestructive inspections beyond the requirements of Section XI of the ASME Code for FW and CRDRL nozzles.

In NUREG-0619, the NRC staff encouraged licensees to continue development of UT techniques for the FW and CRDRL nozzle examinations. The NUREG states that the historical results from inservice UT examinations and the demonstration of UT techniques to detect small nozzle thermal fatigue cracks on the inner radius and bore of the nozzle with acceptable reliability and consistency could form the basis for proposing modifications of the inspection criteria contained in the NUREG.

During the 18 years since issuing NUREG-0619, significant advances have occurred in UT inspection technology, and significant field experience has been gathered on the successful prevention of cracks in FW and CRDRL nozzles. As a result of these improvements, the BWROG submitted report GE-NE-523-A71-0594 which proposed alternate criteria for the recommendations in NUREG-0619. The alternate criteria are based upon fracture mechanics analyses, inspection data from several BWRs, and the use of currently available advanced UT inspection techniques. In a safety evaluation (SE) dated June 5, 1998, the NRC staff determined that the BWROG's proposed alternative for FW nozzles is acceptable with modifications. The SE did not address the CRDRL nozzle.

2.0 PURPOSE OF REQUEST

The purpose of NMPC's letters was to inform the NRC of changes in NMPC's initial commitment with respect to NUREG-0619 recommendations, and to explain those changes.

3.0 INSPECTIONS

3.1 Requirements

For NMP1, NMPC is required to perform nondestructive examinations to the 1983 Edition, with Summer 1983 Addenda, of Section XI of the ASME Code. Minimum ASME UT examination requirements for the inner radii of the FW and CRDRL nozzles are given in Table IWB-2500-1, Examination Category B-D, Item No. B3.100.

3.2 NMPC's Initial Commitment

In a letter dated December 29, 1980, NMPC committed to the inspection intervals outlined in NUREG-0619. In NUREG-0619, Paragraph 4.3.2, Table 2, UT inspections of the FW nozzles are to be performed every other refueling outage and visual testing (VT) inspections of the feedwater spargers are to be performed every fourth refueling outage. PT inspections are to be performed as required on FW nozzles every sixth refueling outage, or every 90 startup/shutdown cycles, whichever occurs first.

NMPC committed to perform PT inspections on the CRDRL nozzle at the same frequency as PT inspections of the FW nozzles in accordance with NUREG-0619, Paragraph 8.2(5).

4.0 PROPOSED ALTERNATIVE EXAMINATION

NMPC proposes to perform FW nozzle inspections at NMP1 using the NRC-approved recommendations in BWROG Report GE-NE-523-A71-0594, subject to the modifications identified in the NRC's related letter and SE dated June 5, 1998. NMPC proposes to eliminate periodic PT examinations of the CRDRL nozzle and perform ASME Code inspections using enhanced UT techniques. The UT examinations for FW and CRDRL nozzles will be in accordance with the prescriptive ASME Code requirements. These UT examinations will be performed using the GERIS 2000 system that is described in the aforementioned letters changing NMPC's commitment.

5.0 EVALUATION

NMP1 began operation in late 1969 and has been in service for approximately 26 years. In 1977 thermal fatigue cracks were found on the inner radii of the FW nozzles. These cracks were removed. Examinations performed on the CRDRL inner nozzle radii did not detect any thermal fatigue cracks. To prevent reoccurrence of cracks in the FW nozzle radii, the FW spargers were replaced with an improved single-piston ring/flow baffle seal design. Along with the improved FW spargers design, NMPC implemented other recommended actions contained in NUREG-0619 to minimize the potential for the initiation and growth of thermal fatigue cracks.

5.1 Inservice Inspection History

In response to NRC staff requests for additional information, NMPC described the UT, VT, and PT examinations for NMP1's FW and CRDRL nozzles from 1977 through 1995. Starting in 1977, four FW Nozzles were UT examined from the reactor pressure vessel exterior using procedures and techniques developed by General Electric Company (GE). These examinations formed the baseline for the reconditioned nozzle inner radii and bore. Starting in 1979, UT and PT examinations of the four FW nozzles were performed by GE with no significant changes from the baseline. At the same time, the reactor water cleanup return line was rerouted to the FW lines. Starting in 1981, the spargers were VT examined and were scheduled for examination every fourth refueling outage.

In a letter dated October 3, 1995, NMPC submitted a report to the NRC staff on the FW and CRDRL nozzle examinations performed during refueling outage 13. The report included a summary of examination results from 1977 through 1995. For the FW nozzles, UT examinations performed in 1981 and 1983 revealed indications that were dispositioned as geometric reflectors, the 1981 PT examination revealed minor surface irregularities, and the 1981 VT examination revealed a cracked bracket pin that was subsequently repaired. For the CRDRL nozzle, UT and PT examinations revealed no reportable indications.

5.2 Fracture Mechanics Analysis of Nozzles

The configurations of the thermal sleeves in the NMP1 FW nozzles feature a double flow baffle arrangement that provides an additional barrier separating nozzle bypass flow and the free stream vessel flow. The baffle plates are spring loaded against the reactor pressure vessel surface to prevent leakage that could establish water flow capable of inducing high cycle transient thermal loadings in the nozzle-to-vessel inner wall. Therefore, the high cycle fatigue loading should have negligible impact upon the nozzle loading. Consequently, the primary transient thermal loads are a result of plant transients (i.e., startup, shutdown, and scrams) which significantly change the flow rate through these nozzles. During these transients, large flow rate variations through each nozzle will establish a large temperature gradient across the flow baffles and along the nozzle wall, thus inducing thermal stresses in the material. NMPC determined the nozzle stress fields by performing 3-dimensional thermal-mechanical finite element analysis of the nozzle area. NMPC then used the resultant nozzle loads to calculate the applied stresses necessary to inhibit fatigue crack growth. Using the crack growth acceptance criteria from NUREG-0619 (a 0.25 inch deep crack would not grow more than 1.0 inch in 40 years), NMPC's stress analysis determined that a 40-year crack growth for a 0.25 inch deep crack in the FW nozzles would be 0.13 inch in the blend region and 0.08 inch in the bore. On the basis of these calculations, cracks in the FW nozzles would not exceed allowable values in Section XI of the ASME Code during the remainder of NMP1's operating life.

The configuration of thermal sleeves in the CRDRL nozzle at NMP1 is a sleeve welded into the nozzle safe-end that extends into the reactor pressure vessel. The welded sleeve prevents the cooler CRDRL water from directly contacting the inner nozzle surface, thus preventing crack initiation and growth. However, in the event that a crack did occur, the stress analysis for crack growth is similar to the stress analysis for FW nozzles. NMPC's stress analysis determined that a 40-year crack growth for a 0.25 inch deep crack in the CRDRL nozzles would be 0.15 inch in the blend region. Based upon these calculations, cracks in the CRDRL nozzle would not exceed allowable values in Section XI of the ASME Code during the remainder of NMP1's operating plant life.

5.3 UT Technique

NMPC is using GE's GERIS-2000 system to perform automated contact pulse-echo UT examinations of the FW and CRDRL nozzles according to the prescriptive ASME Code requirements. The GERIS-2000 system was demonstrated on nozzles containing cracks and notches with a procedure that depends upon echo-dynamic motion and tip diffraction characteristics of a flaw. The GERIS-2000 system inspection procedure being used at NMP1 specifies an operating sensitivity for detecting flaws that is more sensitive than the ASME Code requirements.

5.4 Proposed Alternative

In its letter dated September 4, 1998, NMPC modified its commitment contained in letters dated June 23, 1994, and December 15, 1995, to perform periodic inspections of the FW nozzles in accordance with the recommendations in NUREG-0619. As an alternative to the recommendations in NUREG-0691, NMPC proposes to conduct FW nozzle inspections using the recommendations in the BWROG Report GE-NE-523-A71-0594, subject to the modifications identified in the NRC staff's related letter and SE dated June 5, 1998. On the basis of the NRC staff's June 5, 1998, letter and SE, the proposed alternative stated in NMPC's September 4, 1998, letter is acceptable for NMP1 FW nozzles inspections.

In the September 4, 1998, letter, NMPC reaffirmed its commitment to perform periodic inspections of the NMP1 CRDRL nozzle in accordance with NUREG-0619, as amended by its letter of June 23, 1994 (i.e., eliminating PT examinations), and supplemented December 15, 1995. NMPC will continue to perform UT examinations of the CRDRL nozzle in accordance with ASME Code requirements using the GERIS-2000 system, operating with a sensitivity for detecting flaws that exceeds the requirement of NMP1's ASME Code of record. Using such procedures, the GERIS-2000 system successfully demonstrated the ability to detect and size flaws with through-wall depths of 0.25 inch and greater in the nozzle-to-vessel inner radii. This GERIS-2000 UT technique is an improvement over the UT techniques that were in use at the time NUREG-0619 was issued.

6.0 CONCLUSION

On the basis of the above evaluation, the NRC staff concludes that NMPC's commitment for FW nozzle blend radii UT examinations, described in letters dated June 23 and September 12, 1994, and December 15, 1995, as modified by letter dated September 4, 1998, will provide an acceptable level of quality and safety. Similarly, NMPC's current commitment to perform periodic inspections of the NMP1 CRDRL nozzle in accordance with NUREG-0619, as amended by letter dated June 23, 1994, as supplemented by letters dated September 12, 1994, and December 15, 1995, and reaffirmed by letter dated September 4, 1998, will provide an acceptable level of quality and safety.

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