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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ALTERNATIVES FOR EXAMINATION OF

REACTOR PRESSURE VESSEL SHELL WELDS

NINE MILE POINT NUCLEAR STATION, UNIT NO. 1

DOCKET NO. 50-220

1.0 INTRODUCTION

By letter dated December 10, 1998, Niagara Mohawk Power Corporation (NMPC and the licensee) requested that the NRC approve an alternative to performing circumferential shell weld examinations on the reactor pressure vessel (RPV) welds at Nine Mile Point Nuclear Station, Unit 1 (NMP1). Those examinations are required by Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), and by the augmented examination requirements of Section 50.55a(g)(6)(ii)(A)(2) to Title 10 of the Code of Federal Regulations (10 CFR 50.55a(g)(6)(ii)(A)(2)). The alternative was proposed pursuant to the provisions of 10 CFR 50.55a(a)(3)(i) and 10 CFR 50.55a(g)(6)(ii)(A)(5), and is consistent with the guidance provided in Generic Letter (GL) 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief From Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds."

NMPC also requested approval of an alternative to the examination requirements specified in 10 CFR 50.55a(g) for the volumetric examination of longitudinal RPV shell welds and the shell-to-flange weld (ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, Item 1.12, Longitudinal Shell Welds and Item 1.30, Shell-to-Flange Weld). This proposed alternative was requested pursuant to 10 CFR 50.55a(a)(3)(i) and 10 CFR 50.55a(g)(6)(ii)(A)(5). NMPC proposed to perform an automated inspection of certain RPV welds using personnel and procedures qualified to the "Performance Demonstration Initiative" (PDI). The automated examinations would be performed using the General Electric Remote Inspection System (GERIS-2000).

NMPC would perform examinations of the longitudinal RPV shell welds as scheduled, and approximately 2 to 3 percent of the circumferential seam welds would be examined at their points of intersection with the longitudinal welds. This would be done in accordance with the revised BWRVIP-05 report and the ASME Code requirements (i.e., one-third of the welds are to be inspected every 40 months of the current 10-year interval).

Enclosure

1.1 Regulatory Requirements

Pursuant to the requirements of 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components are to meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of the ASME Code, Section XI, incorporated by reference in 10 CFR 50.55a(b) on the date twelve months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The applicable ASME Code, Section XI, for NMP1 during its second 10-year ISI interval is the 1983 Edition, through the Winter Addenda.

10 CFR 50.55a(g)(6)(ii)(A) requires that licensees perform an augmented RPV shell weld examination as specified in the 1989 Edition of Section XI of the ASME Code. The final Rule was published in the *Federal Register* on August 6, 1992 (57 FR 34666). By incorporating into the regulations the 1989 Edition of the ASME Code, the NRC staff required that licensees perform volumetric examinations of "essentially 100 percent" of the RPV pressure-retaining shell welds during all inspection intervals. 10 CFR 50.55a(a)(3) states that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

1.2 BWRVIP-05

By letter dated September 28, 1995, as modified and supplemented by letters dated June 24 and October 29, 1996, and May 16, June 4, June 13 and December 18, 1997, the Boiling Water Reactor Vessel and Internals Project (BWRVIP), submitted the proprietary report BWRVIP-05, "BWR Vessel and Internals Project, BWR Reactor Vessel Shell Weld Inspection Recommendations." In this report, BWRVIP proposed to reduce the scope of inspection of the BWR RPV welds from essentially 100 percent of all RPV shell welds to the examination of essentially 100 percent of the axial welds and inspecting essentially none of the circumferential RPV shell welds, except that the intersection of the axial and circumferential welds would have included approximately 2-3 percent of the circumferential welds.

On May 12, 1997, the NRC staff and members of the BWRVIP met with the Commission to discuss the NRC staff's review of the BWRVIP-05 report. In accordance with guidance provided by the Commission in Staff Requirements Memorandum (SRM) M970512B, dated May 30, 1997, the NRC staff initiated a broader, risk-informed review of the BWRVIP-05 proposal. The NRC staff issued a final safety evaluation related to the review of BWRVIP-05 on July 28, 1998, which generically approved the reduction in inspection of circumferential RPV welds.

1.3 Generic Letter 98-05

On November 10, 1998, the NRC issued Generic Letter (GL) 98-05. GL 98-05 stated that BWR licensees may request permanent (i.e., for the remaining term of operation under the existing, initial, license) relief from the inservice inspection requirements of 10 CFR 50.55a(g) for the volumetric examination of circumferential reactor pressure vessel welds (ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, Item 1.11, Circumferential Shell Welds) by demonstrating that: (1) at the expiration of the license, the circumferential welds will continue to satisfy the limiting conditional failure probability for circumferential welds in the NRC staff's July 30, 1998, safety evaluation, and (2) licensees have implemented operator training and established procedures that limit the frequency of cold over-pressure events to the amount specified in the NRC staff's July 30, 1998, safety evaluation. Licensees would still need to perform the required inspections of "essentially 100 percent" of all axial welds.

2.0 <u>LICENSEE'S PROPOSED ALTERNATIVE</u>

NMPC proposed; as an alternative, to defer permanently the full ultrasonic examination of the RPV circumferential shell welds for the duration of the NMP1 operating license (i.e., until August 22, 2009). NMPC would perform examinations of the longitudinal RPV shell welds as scheduled, and approximately 2 to 3 percent of the circumferential seam welds would be examined at their points of intersection with the longitudinal welds. Additionally, NMPC requested approval of an alternative to the examination requirements specified in 10 CFR 50.55a(g) for the volumetric examination of longitudinal RPV shell welds and the shell-to-flange weld (ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, Item 1.12, "Longitudinal Shell Welds," and Item 1.30, "Shell-to-Flange Weld"). This proposed alternative was requested pursuant to 10 CFR 50.55a(a)(3)(i) and 10 CFR 50.55a(g)(6)(ii)(A)(5). NMPC proposed to perform an automated inspection of certain RPV welds using PDI qualified personnel and procedures. The automated examinations would be performed using GERIS-2000.

3.0 <u>LICENSEE'S TECHNICAL JUSTIFICATION</u>

NMPC indicated in its December 10, 1998, letter that its request for alternative inspections is based upon the BWRVIP-05 report, which concludes that the probability of failure of BWR RPV circumferential shell welds is orders of magnitude lower than that of the axial shell welds. This conclusion was also reached in the NRC staff's independent assessment of the report.

The NRC staff conducted an independent risk-informed assessment of the analysis contained in BWRVIP-05. This independent NRC assessment utilized the FAVOR Code to perform a probabilistic fracture mechanics (PFM) analysis to estimate RPV failure probabilities. The key parameters in the PFM analysis are the initial reference nil-ductility transition temperature (RT_{NDT}), the end-of-license mean neutron fluence, the mean chemistry composition (percent copper and nickel) of the welds, and the pressure and temperature of the events being considered. Although the BWRVIP-05 report provides the technical basis supporting the alternative, the data presented in Table 1 (shown at the end of this safety evaluation) illustrates that NMP1 has additional conservatism in comparison to the NRC's Independent Assessment Fracture Analysis limiting case. As shown in Table 1, the impact of irradiation

results in lower plant-specific mean RT_{NDT} for the NMP1 circumferential weld material as compared to that for any of the NRC staff's plant-specific analyses performed for Combustion Engineering (CE) fabricated RPV's with the highest adjusted reference temperatures. Comparison of the NMP1 specific data and the data used in the NRC Final Safety Evaluation indicates the difference is the combined effects of the Ni% and Cu% on the Chemistry Factor, which is by itself bounded by the NRC Independent Assessment, and the initial RT_{NDT}. Therefore, the limiting plant-specific conditional probability of failure P(FIE), determined by the NRC, bounds the NMP1 case through the projected end of license.

Thus, the BWRVIP specific results relative to NMP1 as presented in BWRVIP-05 are consistent with those in the NRC Independent Assessment. Both analyses conclude that the failure probability associated with the circumferential welds is extremely small, and that it is orders of magnitude less than that for axial welds. Therefore, the NMP1 circumferential weld satisfies, at the end of the NMP1 operating license, the limiting conditional failure probability for circumferential welds stated in the NRC staff's July 28, 1998, Safety Evaluation.

During review of the BWRVIP-05 report, the NRC staff identified non-design basis events that should have been considered in the analysis. In particular, the potential for and consequences of low temperature overpressure (LTOP) transients should be considered. NMPC states that it has in place, procedural controls which monitor and control reactor temperature and water inventory during cold shutdown, minimizing the likelihood of an RPV LTOP event. These controls are reinforced through NMPC's reactor operator training program.

NMPC states that RPV leakage and hydrostatic pressure test procedures used at NMP1 have sufficient procedural guidance to prevent LTOP. The leakage test is performed at the conclusion of each refueling outage, while the hydrostatic test is performed once every 10 years. These pressure tests are infrequently performed, complex tasks, and the test procedures are controlled as Special Plant Evolutions. As such, a requirement is included in the procedures for an extensive "pre-job" briefing to be conducted with all essential personnel, including Operations management. The briefing discusses the anticipated testing evolution, with special emphasis on conservative decision making, plant safety awareness, lessons learned from similar in-house or industry operating experiences, the importance of open communications, and the process in which the test would be aborted if plant systems responded in an adverse manner. Vessel pressure and temperature are required to be monitored throughout the tests to ensure compliance with NMP1's Technical Specification pressure-temperature curve limits. Also, the procedures require the designation of a "Principal Test Engineer" for the duration of the test who is a single point of accountability, responsible for coordinating testing from initiation to closure, and keeping operations and plant management informed of the test status.

With regard to inadvertent system injection resulting in an LTOP condition, the NMP1 high pressure makeup system, (i.e., the high pressure coolant injection (HPCI)) as well as the normal feedwater system are interconnected. The portion of the system for HPCI operation is comprised of two motor-driven condensate, feedwater booster and feedwater pumps. HPCI is a mode of operation of the Condensate and Feedwater systems rather than an independent, stand alone system. As such, the HPCI system contains only instrumentation and control components as its own dedicated equipment. HPCI initiation is prompted by the Reactor

Protection System under the following conditions: 1) a turbine trip, or 2) low reactor water level. During shutdown of the unit, the associated booster and feedwater pumps in the system are secured in accordance with operating procedures. Equipment malfunction or inappropriate operational action would be necessary to cause inadvertent system operation.

During normal cold shutdown conditions, with the RPV head installed, RPV level and pressure are controlled with the Control Rod Drive System, Condensate Feedwater System, and Reactor Water Cleanup (RWCU) System using a "feed and bleed" process. The RPV is not taken solid during these times, and plant procedures require opening of the head vent valves after the reactor has been depressurized to approximately 15 psig.

The Liquid Poison System is another high pressure water source to the RPV, however, there are no means of automatic system activation. System injection requires an operator to manually reposition a key-locked control switch to start the system from the Control Room. The system may also be operated from a remote local test station. The only injection path to the RPV is through two explosive actuated injection valves that are interlocked with the key--locked switch in the Control Room. Local testing of the pumps uses demineralized water from a test tank and is a closed test loop. The injection rate for each pump is approximately 30 gpm, which would give the operator sufficient time to control reactor pressure.

Procedural controls are in place to respond to an unexplained rise in reactor pressure which could result from a spurious activation of an injection source. Actions specified include determination and isolation of the pressure source, verification of reactor head vents and/or Main Steam Isolation Valves open and, as necessary, relieving reactor pressure using available plant equipment (e.g., electromagnetic relief valves, reactor water cleanup and reactor bottom drain).

During normal cold shutdown conditions, reactor water level and temperature are maintained within established ranges in accordance with operating procedures. The Operations manual governing Control Room activities requires that the Control Room operators frequently monitor for indications and alarms to detect problems and abnormalities as early as possible. An Operations procedure also requires that the control room supervisor be notified immediately of any change or abnormality in plant indications and controls. Furthermore, reactor water level and temperature operating bands and changes thereto are established under the direction of the Station Shift Supervisor. Therefore, any deviations in reactor-water level or temperature from a specified band will be identified and corrected. Finally, plant conditions and on-going activities are discussed during each shift turnover. This ensures that on-coming operators are cognizant of activities that could adversely affect reactor level, pressure, or temperature.

Plant specific procedures have been developed to provide operator guidance regarding compliance with the plant Technical Specification RPV pressure-temperature curve limits. Additionally, operators receive training on RPV brittle fracture and the relationship of these pressure-temperature curve limits.

During plant outages, NMP1 work control processes ensure that the outage schedule and changes to the schedule receive a thorough shutdown risk assessment review to ensure that defense-in-depth is maintained. Work is coordinated through the Work Control Center which

provides an additional level of Operations oversight. In the Control Room, the Station Shift Supervisor is required to maintain cognizance of any activity that could potentially affect reactor safety during refueling outages. Expected plant responses and contingency actions to address unexpected conditions, that may be encountered, are required to be evaluated as stated in the administrative controls for risk management and management of outages.

As discussed above, NMPC indicates that they have implemented procedural controls and training to minimize the probability of an LTOP event. Accordingly, the above information and the supporting technical documentation contained in the BWRVIP-05 report and NRC Safety Evaluation provide a basis for excluding RPV circumferential welds from the augmented examination requirements of 10 CFR 50.55a(g) and ASME Section XI.

NMP1 has an RPV that was designed and fabricated to the rules of ASME Sections I and VIII, including Nuclear Code Cases 1270N and 1273N. Additionally, General Electric's Specification for design and fabrication included additional requirements for materials and inspection that were similar to ASME Section III. Early vintage plants of this type were designed, fabricated, and erected prior to the examination and inspection requirements of ASME Section XI. Specific ultrasonic (UT) examinations were not required by ASME Sections I, III, or VIII for preservice inspection of the vessel and were not factored into the plant design, hence external access to the RPV axial shell welds is constrained due to inadequate clearances between the bioshield wall and vessel insulation.

The NMP1 examination plan requires examination of 100 percent of all accessible regions of the RPV axial welds. The ability to inspect 100 percent of the axial welds will be limited, in some cases to 57 percent, due to the physical constraints of the RPV internal vessel design and arrangement of internal components. An internal vessel accessibility study of the RPV was performed by General Electric to determine the inspectability of the RPV axial shell welds and to obtain clearance measurements for the GERIS-2000. Several internal vessel components will limit a 100 percent inside-diameter UT examination including interference from the Feedwater Sparger, Specimen Brackets, Vibration Brackets, the Shroud Support Baffle Plate, and Shroud Repair Tie Rod Assembly. Even with these limitations, the overall projected percentage of effective weld examination coverage in the beltline region is approximately 92 percent. NMPC has provided in Tables 2 and 3 of its December 10, 1998 submittal, an illustration of the anticipated examination coverage of the axial welds during the forthcoming refueling outage (RFO15) showing a range of examination coverage of 57 to 100 percent. Also Included in Table 3 of the December 10, 1998 submittal is a column identifying the specific limitation precluding essentially 100 percent of the axial shield welds. The submittal includes a drawing that provides the location of the welds in relation to the RPV.

NMPC concluded that permanent deferral of the examination of the RPV circumferential shell welds for the life of the operating license and the reduced examination coverage of the axial welds is justified and presents an acceptable level of quality and safety to satisfy the requirements of 10 CFR 50.55a(a)(3)(i), 10 CFR 50.55a(a)(3)(ii), and 10 CFR 50.55a(g)(6)(ii)(A)(5).

NMPC requested approval of an alternative to the examination requirements specified in 10 CFR 50.55a(b)(2) for the volumetric examination of longitudinal RPV shell welds and the

shell-to-flange weld (ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, Item 1.12, Longitudinal Shell Welds and Item 1.30, Shell-to-Flange Weld). Specifically, NMPC proposed to perform an automated inspection of these RPV welds using PDI qualified personnel and procedures. The examinations will be performed using GERIS-2000. The GERIS-2000 system and procedures were demonstrated and qualified to the satisfaction of PDI and in accordance with ASME Section XI, 1992 Edition with the 1993 Addenda, Appendix VIII.

The examination procedure uses echo-dynamic motion and tip diffraction characteristics of flaws for detection and sizing in lieu of ASME Code amplitude based techniques. All accessible weld examination volumes will be interrogated by the same straight and angle beam search units required by ASME Section V, Article 4 and an additional 70 degree refracted longitudinal search unit will be employed to ensure adequate investigation of the RPV axial weld clad base metal interface.

The use of PDI qualified personnel and procedures results in a more sensitive examination and will provide added assurance for flaw detection and sizing, and is thereby an acceptable alternative to the requirements of the 1989 Edition of the ASME Section XI Code and Regulatory Guide 1.150. The error band for flaw sizing has been established within the limits of ASME Section XI, Appendix VIII.

4.0 NRC STAFF'S EVALUATION

The NRC staff confirmed that the RT_{NDT} values for the circumferential welds at the end of the relief period are less than the values in the reference case and uncertainty analysis for the CE fabricated vessels. RT_{NDT} is a measure of the amount of irradiation embrittlement. Since the RT_{NDT} values are less than the values in the reference case and the uncertainty analysis for CE fabricated vessels, the NMP1 RPV will have less embrittlement than the reference case and will have a conditional probability of vessel failure no more than that estimated in the NRC staff's assessment.

The NRC staff reviewed the information provided by NMPC regarding the NMP1 high pressure injection systems, operator training, and plant-specific procedures to prevent RPV cold overpressurization. The information provided sufficient basis to support approval of the request to defer permanently the ultrasonic examination of the RPV circumferential shell welds for the duration of the NMP1 operating license. The NRC staff concludes that the probability of a non-design basis cold overpressure transient occurring at NMP1 during the requested delay is low, which is consistent with the NRC staff's assessment.

The NRC staff also reviewed NMPC's basis for not being able to perform 100 percent examination of all accessible regions of the RPV axial welds and shell-to-flange welds. NMPC has stated that the ability to inspect 100 percent of the axial welds is limited, in some cases, because of physical constraints of the RPV internal vessel design and arrangement of internal components. Nevertheless, even with these limitations, NMPC has estimated that the projected percentage of effective weld examination coverage in the beltline region will be approximately 92 percent. This level of coverage, in conjunction with the complete coverage for the majority of welds, should be able to detect any existing patterns of degradation being present in the RPV welds. The welds will be examined using the GERIS-2000 system and PDI qualified

personnel and procedures. Use of the GERIS-2000 system and PDI qualified personnel and procedures will provide added assurance of flaw detection and sizing. The NRC staff concludes that NMPC has provided sufficient justification to establish that the requirements of 10 CFR 50.55a(g)(6)(ii)(A)(2) cannot be fully satisfied for the NMP1 RPV welds and NMPC's proposed alternative examinations provide reasonable assurance that any unacceptable degradation of the RPV welds will be detected.

The NRC staff also reviewed NMPC's request to use alternative examination for the shell-to-flange RPV weld. The request is to use an alternative examination technique using PDI qualified examination procedures and personnel in lieu of those examination methods and techniques specified in NMPC's current ISI Program. The proposed exam method which may not satisfy the examination coverage requirement for augmented RPV examination as stated in 10 CFR 50.55a(g)(6)(ii)(A). This request applies to the current ISI inspection interval scheduled to conclude on or about December 1999. The welds will be examined using GERIS-2000. Based on previous industry experience, the use of GERIS-2000 and PDI qualified personnel and procedures will provide added assurance of flaw detection and sizing, even in those instances where the coverage may be less than 90 percent. Consequently, any unacceptable degradation or flaw, should it exist, will be detected. The NRC staff concludes that NMPC has proposed an acceptable alternative to the ASME Code Section XI requirements for the NMP1 RPV shell-to-flange weld.

5.0 CONCLUSIONS

On the basis of its review, the NRC staff concludes that NMPC has provided an acceptable alternative to the requirements of the ASME Code, Section XI and 10 CFR 50.55a(g)(6)(ii)(A). This conclusion is based on the following considerations:

(1) Based upon NMPC's assessment of the materials in the circumferential welds in the NMP1 RPV, the conditional probability of vessel failure should be less than or equal to that estimated from the NRC staff's assessment.

(2) Based upon NMPC's high pressure injection systems analyses, operator training, and plant-specific procedures, a non-design basis cold over-pressure transient is unlikely to occur at NMP1 during the requested delay.

(3) Based upon the above, the NMP1 RPV can be operated during the requested delay period with an acceptable level of quality and safety, and the inspection of the circumferential welds may be delayed permanently for the duration of the NMP1 operating license.

(4) Based upon the information submitted by NMPC, NMPC has proposed an acceptable alternative to the ASME Code required 100 percent examination of all accessible regions of the RPV axial welds and shell-to-flange weld. NMPC has stated that the projected percentage of effective weld examination coverage in the beltline region will be approximately 92 percent. This level of coverage, in conjunction with the complete coverage for the majority of welds, should be able to detect any existing patterns of degradation being present in the RPV welds.

The NRC staff concludes that authorization of NMPC's alternative programs would provide assurance of structural integrity and, therefore, an acceptable level of quality and safety. Accordingly, pursuant to 10 CFR 50.55a(g)(6)(ii)(A)(5) and 10CFR50.55a(a)(3)(i), the alternative are authorized, and are effective from the date of this SE until the expiration of the operating license (August 22, 2009) limit.duration of relief.

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Date: April 7, 1999

TABLE 1

Parameter Description	NMP1 Parameters at 32 EFPY(Bounding Circumferential Weld)	USNRC Limiting Plant Specific Analysis Parameters at 32 EFPY SE Table 2.6-4	
		SE "VIP"	SE "CEOG"
Fluence, n/cm^2	2.21 x 10^{18}	2.0 x 10^{18}	2.0 x 10^{18}
Initial RT_{NDT}, °F	-50	0	0
Chemistry Factor, °F	112	151.7	172.2
Cu%	0.22*	0.13	0.183
Ni%	0.20*	0.71	0.704
ΔRT_{NDT} °F	66.5	86.4	98.1
Mean RT_{NDT} °F	16.5	86.4	98.1

* The Cu% and Ni% bounds the maximum GL 92-01 NMP1 weld chemistry variability as documented in NMPC's September 4, 1998 reply to NRC requests for additional information.