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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE TO INSPECTION OF REACTOR PRESSURE VESSEL

CIRCUMFERENTIAL WELDS

DETROIT EDISON COMPANY

FERMI 2

DOCKET NO. 50-341

1.0 INTRODUCTION

By letter dated September 11, 1998, as supplemented on February 12, 1999, Detroit Edison Company (the licensee) requested NRC approval of an alternative to performing the reactor pressure vessel (RPV) circumferential shell weld examinations requirements of both the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 1992 Edition, with portions of the 1993 Addenda (inservice inspection), and the augmented examination requirements of 10 CFR 50.55a(g)(6)(ii)(A)(2) for the Fermi 2 RPV. 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 information contained in Information Notice (IN) 97-63, Supplement 1, "Status of NRC Staff's Review of BWRVIP-05," dated May 7, 1998.

The licensee proposed to perform examinations of the longitudinal RPV shell welds as scheduled, with approximately 5 percent of the circumferential seam welds examined at their points of intersection with the longitudinal welds. This would be done in accordance with the BWRVIP-05 and the ASME Code requirements (i.e., one-third of the welds inspected each 40 months of the current 10-year interval). Additionally, a partial examination of one of the four circumferential welds was completed during the second refueling outage.

Pursuant to the requirements of 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components must 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 12 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 Fermi 2, during the current 10-year inservice inspection interval is the 1980 Edition, with Winter 1981 Addenda.

Licensees are required, by 10 CFR 50.55a(g)(6)(ii)(A), to perform an expanded RPV shell weld examination as specified in the 1989 Edition of Section XI of the ASME Code. The 1989 Edition of the ASME Code specifies that licensees shall perform volumetric examinations of "essentially 100 percent" of the RPV pressure-retaining shell welds during all inspection intervals. In accordance with 10 CFR 50.55a(a)(3)(i), alternatives to the requirements in 10 CFR 50.55a(g) may be authorized when the proposed alternative provides an acceptable level of quality and safety.

By letter dated September 28, 1995, as 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), a technical committee of the BWR Owners Group, submitted its report, "BWR Vessel and Internals Project, BWR Reactor Vessel Shell Weld Inspection Recommendations (BWRVIP-05)," (EPRI report TR-105697, proprietary information. Not publicly available.) which proposed to reduce the scope of inspection of the BWR RPV welds. The BWRVIP initially proposed to reduce the scope from essentially 100 percent of all RPV shell welds to 50 percent of the axial welds and 0 percent of the circumferential welds. However, by letter dated October 29, 1996, the BWRVIP modified its proposal to increase the examination of the axial welds to 100 percent from 50 percent while still proposing to inspect essentially 0 percent 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 M970512B, dated May 30, 1997, the staff has initiated a broader, risk-informed review of the BWRVIP-05 proposal. The 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.

In IN 97-63, Supplement 1, the staff indicated that it would consider technically justified alternatives to the augmented examination in accordance with 10 CFR 50.55a(a)(3)(i), 10 CFR 50.55a(a)(3)(ii), and 50.55a(g)(6)(ii)(A)(5), from BWR licensees who are scheduled to perform inspections of the BWR RPV circumferential welds during the fall 1998 or spring 1999 outage seasons. Properly justified alternatives would be considered for inspection delays of up to 40 months or two operating cycles (whichever is longer) for BWR RPV circumferential shell welds only.

2.0 BACKGROUND - STAFF ASSESSMENT OF THE BWRVIP-05 REPORT

The staff's independent assessment of the BWRVIP-05 proposal is documented in a letter dated August 14, 1997, to Mr. Carl Terry, BWRVIP Chairman. The staff concluded that the industry's assessment did not sufficiently address risk, and additional work was necessary to provide a complete risk-informed evaluation. The staff's assessment was performed for BWR RPVs fabricated by Chicago Bridge and Iron (CB&I), Combustion Engineering (CE), and Babcock and Wilcox (B&W). The staff assessment identified pressure and temperature resulting from a cold overpressure event in a foreign reactor as the limiting event for BWR RPVs. The materials and neutron radiation parameters used by the staff are identified in Table 7-1 of the staff's

independent assessment. The staff determined the conditional probability of failure for axial and circumferential welds fabricated by CB&I, CE, and B&W. Table 7-9 of the staff's assessment identifies the conditional probability of failure for the reference cases and the 95 percent confidence uncertainty bound cases for axial and circumferential welds fabricated by CB&I, CE, and B&W. B&W fabricated vessels were determined to have the highest conditional probability of failure. The input material parameters used in the analysis of the reference case for B&W fabricated vessels resulted in a reference temperature (RT_{NDT}) at the vessel inner surface of 114.5 °F. In the uncertainty analysis, the neutron fluence evaluation had the greatest RT_{NDT} value (145 °F) at the inner surface. Vessels with RT_{NDT} values less than those resulting from the staff's assessment will have less embrittlement than the vessels simulated in the staff's assessment and should have a conditional probability of vessel failure less than or equal to the values in the staff's assessment.

The failure probability for a weld is the product of the critical event frequency and the conditional probability of the weld failure for that event. Using the event frequency for a cold overpressure event and the conditional probability of vessel failure for CE-fabricated circumferential welds, the best-estimate failure frequency from the staff's assessment is $<6\times10^{-11}$ [(1)] per reactor year and the upper bound failure frequency from the uncertainty analysis is $<2.8\times10^{-10}$ [(1)] per reactor year. The BWRVIP-05 report was a generic topical report addressing all BWR RPVs. The staff's independent analysis applied additional conservatism to the BWRVIP-05 analysis and is considered generic. If a BWR licensee can demonstrate the results of the analysis of its RPV circumferential welds are bounded by the staff's assessment, then the staff could conclude that deferral of the inspection of those welds is acceptable from the perspective of embrittlement and conditional probability of vessel failure. However, licensees would also have to address the prevention of cold overpressure events, including associated procedures and operator training, in order for the staff to reach an overall conclusion whether the deferral was acceptable.

3.0 EVALUATION

3.1 Proposed Alternative

The alternative proposed by the licensee is to defer the full ultrasonic examination of the RPV circumferential shell welds for a period of 40 months. The licensee will perform examinations of the longitudinal RPV shell welds as scheduled, and approximately 5 percent of the circumferential welds will be examined at their points of intersection with the longitudinal welds.

3.2 Licensee's Technical Justification

3.2.1 RPV Embrittl

The licensee indicated in its September 11, 1998, letter that the basis for requesting the alternative inspections is the BWRVIP-05 report, which stated that the probability of failure of

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[(1)] Because the failure probabilities for the circumferential welds were very low, there were insufficient failures to accurately determine reference case failure probability and sensitivity to flaw size, flaw density, and inservice inspection.

BWR RPV circumferential shell welds is orders of magnitude lower than that of the axial shell welds. This conclusion was also demonstrated in the staff's independent assessment of the report.

The NRC staff has 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 RT_{NDT}, the end of license mean neutron fluence, the mean chemistry (percent copper and nickel) of the welds, and the pressure and temperature of the events being considered. Although BWRVIP-05 provides the technical basis supporting the alternative, the following table illustrates that Fermi 2 has additional conservatism in comparison to the NRC's Independent Assessment Fracture Analysis limiting case.

Parameter Description	**Fermi Unit 2 RPV Shell Weld Information (Bounding Circ. Weld)**	**NRC Independent Assessment Fracture Analysis-- Parameters For CE Vessels (CE case which yielded highest ART)**
Fluence @ end of requested relief period, n/cm^2	2.0×10^{17}	3.26×10^{18}
Initial RT_{NDT}, °F	-50	-56
Chemistry Factor, °F	236	195
Cu%	0.23	0.226
Ni%	1.0	0.76
ΔRT_{NDT}, °F	31.6	135
Margin Term, °F	31.6	58.5
Mean Adjusted Reference Temperature (ART), °F ($RT_{NDT(u)} + \Delta RT_{NDT}$)	-18.4	79
Upper Bound ART, °F ($RT_{NDT(u)} + \Delta RT_{NDT}$ + Margin)	13.2	137.5

The chemistry factor, ΔRT_{NDT}, margin term, mean ART, and upper bound ART are calculated consistent with the guidelines of Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Revision 2. Since the upper bound ART for the bounding Fermi Unit 2 circumferential weld is less than the value from the NRC independent assessment, the licensee concluded that the Fermi 2 circumferential welds are bounded by the staff's assessment, thus providing additional assurance that the vessel welds are also bounded by the BWRVIP-05 report.

3.2.2 Potential For Cold Overpressure Events

During its review of the BWRVIP-05 report, the staff identified non-design-basis events that should have been considered in the analysis. In particular, the potential for and consequences of cold overpressure transients should be considered. The licensee assessed the systems that could lead to a cold overpressure transient for the Fermi 2 RPV. These included the high pressure core injection (HPCI), reactor core isolation cooling (RCIC), normal feedwater supply, standby feedwater (SBFW), core spray (CS), residual heat removal (RHR), control rod drive (CRD) and reactor water cleanup (RWCU) systems.

The HPCI and RCIC pumps are steam driven and do not function during cold shutdown. The reactor feedwater pumps are the high pressure makeup system during normal operations. The reactor feedwater pumps are also steam driven and therefore, cannot be operated during cold shutdown. The SBFW system requires deliberate operator action to initiate injection. The licensee stated that procedures are in place to administratively control the use of the SBFW system. Although not addressed in the licensee's submittal, the staff notes that generally there are no automatic starts associated with the standby liquid control system (SLCS). Operator initiation of SLCS should not occur during shutdown; however, the SLCS injection rate of approximately 40 gallons per minute would allow operators sufficient time to control reactor pressure if manual initiation occurred.

The CS and RHR systems are low pressure emergency core cooling systems with shutoff heads below 400 psig. If either one of these systems were manually or inadvertently initiated during cold shutdown, the resulting reactor pressure and temperature would be below the pressure-temperature limits. The CRD and RWCU systems are operated using a feed and bleed process to control RPV level and pressure during normal cold shutdown conditions. Plant procedures are in place to respond to any unexpected or unexplained rise in reactor water level which could result from spurious actuation of an injection system. The procedure actions include preventing condensate pump injection, securing emergency core cooling system injection, tripping CRD pumps, terminating all other injection sources, and lowering RPV level via the RWCU system.

In all cases, the operators are trained in methods of controlling water level within specified limits in addition to responding to abnormal water level conditions during shutdown. The licensee also stated that procedural controls for reactor temperature, level, and pressure are an integral part of operator training. Plant-specific procedures have been established to provide guidance to the operators regarding compliance with the technical specification pressure-temperature limits. On the basis of the pressure limits of the operating systems, operator training, and established plant-specific procedures, the licensee determined that a non-design-basis cold overpressure transient is unlikely to occur during the requested delay.

3.3 Staff Review of Licensee Technical Justification

The staff reviewed the information provided by the licensee regarding the RPV circumferential shell welds and concluded 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 Fermi 2 RPV will have less embrittlement than the reference case and will have a conditional probability of vessel failure less than or equal to that estimated in the staff's assessment.

The staff reviewed the information provided by the licensee regarding the Fermi 2 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 alternative examination request. The staff concludes that the probability of a non-design-basis cold overpressure transient occurring at Fermi 2 during the requested delay is low, which is consistent with the staff's independent assessment in relation to the BWRVIP-05 report.

4.0 CONCLUSIONS

Based upon its review, the staff reached the following conclusions:

(1) Based on the licensee's assessment of the circumferential welds in the Fermi Unit 2 RPV, the staff concludes that the conditional probability of vessel failure should be less than or equal to that estimated from the staff's assessment.

(2) Based on the licensee's high pressure injection systems analyses, operator training, and plant-specific procedures, the staff concludes that a non-design-basis cold overpressure transient is unlikely to occur at Fermi 2 during the requested delay.

(3) Based on the above, the staff concludes that the Fermi Unit 2 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 for the requested 40 months.

Therefore, the proposed 40-month postponement of beginning the augmented examination requirements of 10 CFR 50.55a(g)(6)(ii)(A)(2) at Fermi 2 for circumferential shell welds is authorized pursuant to 10 CFR 50.55a(a)(3)(i), because the alternative to the ASME Code requirements provides an acceptable level of quality and safety at Fermi Unit 2.

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