September 21, 1998

FOR: The Commissioners

FROM: L. Joseph Callan /s/
Executive Director for Operations

SUBJECT: COMPLETION OF STAFF'S REVIEW AND ISSUANCE OF THE FINAL SAFETY EVALUATION REPORT ON REDUCTION IN AUGMENTED EXAMINATION REQUIREMENTS FOR BOILING WATER REACTOR PRESSURE VESSELS PURSUANT TO 10 CFR 50.55a(g)(6)(ii)(A)

PURPOSE:

To inform the Commission of the completion of the NRC staff's review and issuance of a final safety evaluation report (SER) regarding the Boiling Water Reactor Vessel and Internals Project (BWRVIP) proposed reduction in the extent to which boiling water reactor (BWR) licensees inspect their reactor pressure vessels (RPVs) in accordance with the requirements of Section 50.55a(g)(6)(ii)(A) to Title 10 of the *Code of Federal Regulations*, "Augmented Examination of Reactor Vessel," [10 CFR 50.55a(g)(6)(ii)(A)].

BACKGROUND:

By letter dated September 28, 1995, as supplemented by letters dated June 24 and October 29, 1996, May 16, June 4, June 13, and December 18, 1997, and January 13, 1998, the Boiling Water Reactor Vessel and Internals Project (BWRVIP), a technical committee of the BWR Owners Group (BWROG), submitted the Electric Power Research Institute (EPRI) proprietary report TR-105697, "BWR Vessel and Internals Project [BWRVIP], BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations (BWRVIP-05)." The BWRVIP-05 report evaluated the current inspection requirements for the reactor pressure vessel (RPV) shell welds in BWRs, formulated recommendations for alternative inspection requirements, and provided a

technical basis for these recommended requirements. It initially proposed to reduce the scope of inspection of the BWR RPV welds from essentially 100 percent of all RPV shell welds to 50 percent of the axial welds and zero percent of the circumferential welds; however, as modified, it proposed to perform inservice inspections (ISI) on essentially 100 percent of the RPV axial shell welds, and essentially zero percent of the RPV circumferential shell welds, except for the intersections of the axial and circumferential welds. Approximately 2 - 3 percent of the BWR RPV circumferential shell welds will be inspected under this revised proposal.

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In SECY 97-088, dated April 22, 1997, SECY 97-152, dated July 18, 1997, and SECY 97-271, dated November 20, 1997, the staff informed the Commission of the status of the SER being prepared on this issue. Further, on May 12, 1997, the Commission was briefed by representatives of both the BWRVIP and the NRC staff on the issues related to the requirements for a full inspection of BWR RPV shell welds. In response to the Commission's Staff Requirements Memorandum (SRM) M970512B, dated May 30, 1997, the NRC staff initiated a broader, risk-informed review of the BWRVIP-05 proposal. On August 14, 1997, the staff issued an independent safety assessment (ISA) of the BWRVIP-05 document, which was forwarded to the BWRVIP, along with a request for additional information (RAI) to support the staff's risk-informed review. The staff met with the BWRVIP regarding this issue on August 8, 1997. On August 26, 1997, the staff's independent assessment was reviewed by the Advisory Committee on Reactor Safeguards (ACRS) in subcommittee and by the full committee on September 4, 1997. By letter dated September 10, 1997, to Mr. L. Joseph Callan, Executive Director for Operations (EDO), the ACRS made several recommendations regarding this review. The staff forwarded to the BWRVIP, in a letter dated October 10, 1997, an additional RAI based on the ACRS' recommendations.

On August 7, 1997, the staff issued Information Notice (IN) 97-63, "Status of NRC Staff's Review of BWRVIP-05," which stated that the staff would "...consider technically-justified requests for reliefs from 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 shell welds during the fall 1997 or spring 1998 outage seasons. The IN indicates that technically-justified reliefs would be considered for inspection delays of up to two operating cycles for BWR RPV circumferential shell welds only. Licensees will still need to perform their required inspections of "essentially 100 percent" of all axial welds." The acceptability of such requests was based on plant-specific information submitted by the licensee that demonstrated that the expected frequency of beyond-design-basis events, which appeared to dominate the estimated frequency of BWR reactor pressure vessel (RPV) failure, and the level of embrittlement of the RPV were low enough to assure low probability of vessel failure during the period of relief. The staff issued scheduler reliefs for inspections of the BWR RPV circumferential shell welds due during the fall 1997 outage season for four units who submitted technically-justified requests.

On May 7, 1998, the staff issued IN 97-63, Supplement 1, which informed BWR licensees that the staff was extending the period in which it would "...consider technically justified requests for relief from the augmented examination in accordance with 10 CFR 50.55a(a)(3)(i), 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 shell welds during the fall 1998 or spring 1999 outage seasons. Acceptably justified relief will be considered for inspection delays of up to two operating cycles for BWR RPV circumferential shell welds only. Licensees will still need to perform their required inspections of "essentially 100 percent" of all axial welds."

DISCUSSION:

The staff has completed the risk-informed review of the BWRVIP-05 report, as supplemented, and finds in the Safety Evaluation (SE) dated July 28,

1998, that elimination of ISI of BWR circumferential vessel shell welds is technically justified. This finding is based on the BWRVIP technical submittals, along with extensive confirmatory analyses conducted by a multi-Office (NRR and RES) team. The staff's independent safety assessment (ISA) dated August 14, 1997, identified significant risk contributors that had not been considered by the industry and provided technical bases for reviewing the BWRVIP's proposal for the BWR fleet, as well as developing the technical and regulatory insights that were necessary to assure that the industry could appropriately delay inspections of the BWR vessel shell circumferential welds for two operating cycles. The final SE provided a more in-depth risk assessment of permanently deferring the examination of the BWR RPV circumferential shell welds, and has led to a better understanding of the aging mechanisms involved in the BWR pressure vessel. However, the probability of failure of the axial shell welds due to cold over-pressure transients appears to be high enough to warrant further investigations, as summarized below. Inspections of axial welds should provide useful information regarding development of service induced degradation, should it occur.

The initial industry review, using importance sampling, generic weld variables and design basis events, determined that the failure frequency of circumferential welds was 2.2×10^{-41}/yr. However, the staff previously concluded, in its ISA, that beyond design-basis events occurring during plant shutdown could lead to cold over-pressure events that could challenge vessel integrity. In response to the staff's ISA and an RAI, the BWRVIP re-estimated the frequency of cold over-pressure events for BWRs and the associated conditional failure probabilities for circumferential and axial welds. The industry's response concluded that condensate and control rod drive pumps could cause conditions that could lead to cold over-pressure events that could challenge vessel integrity. The BWRVIP's revised estimate of the frequency of over-pressurization events that could challenge the RPV is 9.5×10^{-4}/yr for BWR-4 and 9×10^{-4}/yr for BWRs other than BWR-4. The staff, in its confirmatory analyses, and accounting for actual injections which were not included in the BWRVIP analysis, estimates that the total frequency could be as high as 1×10^{-3}/yr.

The staff, in determining the conditional probability of RPV failure, or P(F|E), performed probabilistic fracture mechanics (PFM) analyses of RPVs using the FAVOR code, which was developed by Oak Ridge National Laboratory (ORNL). In their PFM evaluations, the BWRVIP used the proprietary VIPER code. As shown in Table 1, Limiting Vessel Failure Frequencies (32 ESPY), the staff's and BWRVIP's analysis results correspond closely.

The BWR RPV failure frequencies, when the potential for cold over-pressure events is considered, are significantly higher than the 2.2×10^{-41}/yr frequency reported by the BWRVIP in its original BWRVIP-05 report. The failure frequency calculated by the BWRVIP for the limiting circumferential welds was 9.0×10^{-10} /yr [(9.0×10^{-4}/yr event frequency for a BWR-3) x (1.0×10^{-6} conditional probability of failure)]. The limiting plant-specific failure frequency for circumferential welds at 32 effective full power years (ESPY) was independently calculated by the staff was 8.2×10^{-8}/yr [(1×10^{-3}/yr event frequency) x (8.2×10^{-5} conditional probability of failure)]. As depicted in NUREG 1560, Vol. I, core damage frequencies (CDF) for BWR plants were reported to be approximately 10^{-7}/yr to 10^{-4}/yr. In addition, Regulatory Guide (RG) 1.154 indicates that PWR plants are acceptable for operation if the plant-specific analyses predict the mean frequency of through-wall crack penetration for pressurized thermal shock events is less than 5×10^{-6}/yr. Since the failure frequencies for circumferential welds in BWR plants are significantly below the criteria specified in RG 1.154 and the currently reported CDFs of all BWR plants, and since continued future inspections would result in a negligible decrease in an already acceptably low value, elimination of ISI for RPV circumferential welds is justified.

The BWRVIP's January 13, 1998, response to a staff RAI provided a conditional probability of RPV failure, or P(F|E), due to axial welds in BWRs of 1.55×10^{-2} for the limiting BWR plant after 40 years of operation. Combined with the BWRVIP's estimate of the over-pressure event frequency, the total end of license (EOL) RPV failure frequency for axial shell welds in the limiting plant is a relatively high 1.4×10^{-5}/year due to axial weld failure under postulated cold over-pressure conditions. The staff recognizes there are conservatisms in these analyses and the staff, in a RAI dated June 8, 1998, requested that the BWRVIP provide a schedule for determining more realistic estimates of axial weld failure frequencies. By letter dated July 23, 1998, the BWRVIP provided a schedule for responding to this RAI.

Table 1 - Limiting Vessel Failure Frequencies (32 ESPY)

	BWRVIP[(1)]	NRC[(2)]
Circumferential Welds		
Event Frequency (Events per RY)	9×10^{-4}	1×10^{-3}
Limiting P(F|E) (Failures per Event)	1×10^{-6}	8.2×10^{-5}
Vessel Failure Frequency (Failures per RY)	9×10^{-10}	8.2×10^{-8}
Axial Welds		
Event Frequency (Events per RY)	9×10^{-4}	1×10^{-3}
Limiting P(F|E) (Failures per Event)	1.6×10^{-2}	4.4×10^{-1}

Vessel Failure Frequency (Failures per RY)	1.4×10^{-5}	4.4×10^{-4}

(1) From BWRVIP response to staff RAI, dated December 18, 1997

(2) From staff evaluation of BWRVIP RAI response dated December 18, 1997

[Vessel Failure Frequency (Failures per Reactor Year)] =
[Event Frequency (Events per Reactor Year)] x [Limiting P(F|E) (Failures per Event)]

The staff met with the ACRS on July 9, 1998, to discuss the ACRS' review of the staff's final SER. By letter dated July 21, 1998, to Mr. L. Joseph Callan, EDO, the ACRS endorsed "...the staff's recommendation that licensees be granted permanent relief from inservice inspection requirements for volumetric examination of BWR circumferential reactor pressure vessel welds if the licensee can demonstrate that the generic evaluation performed by the staff is applicable to its vessel." Further, the ACRS concurred "...with the staff's request that the BWRVIP provide a plan for follow-up analyses to determine more realistic estimates of the frequency of axial weld failures caused by cold over-pressure events and propose appropriate technical approaches to address this issue." The staff and the BWRVIP have agreed to meet in the near term, after the BWRVIP completes its follow-up analyses on the frequency of axial weld failures.
STATUS:

BWR licensees may request relief from the inservice inspection requirements of 10 CFR 50.55a(g) for 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: (1) at the expiration of their license, the circumferential welds satisfy the limiting conditional failure probability for circumferential welds in this evaluation, and (2) they have implemented operator training and established procedures that limit the frequency of cold over-pressure events to the amount specified in this report. The staff will pursue clarification of this issue in future rulemaking.

The BWRVIP plans to submit an appendix in the September 1999 timeframe to address the implementation of the BWRVIP-05 report for license renewal. The staff will develop a separate conclusion regarding the adequacy of these inspection practices for managing aging effects pursuant to 10 CFR Part 54 in conjunction with its review of that appendix.

The staff issued for public comment (63 FR 42460) a proposed generic letter (GL) informing BWR licensees that relief from circumferential reactor pressure vessel weld examinations, per the proposal in the BWRVIP-05 report, as approved, will be considered on a plant-specific basis. It should also be noted that the staff's SE is limited to the period of the current operating license. The comment period expired with no comments received; therefore, the staff will issue the proposed GL as previously published. The Committee to Review Generic Requirements (CRGR) has reviewed and endorsed the proposed GL, and waived review of the final GL. The requirements for inspection of circumferential reactor vessel welds during a license renewal period will be reassessed, on a plant -specific basis, as part of any BWR license renewal application.

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