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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555
April 19, 1984

TO ALL LICENSEES OF OPERATING REACTORS, APPLICANTS FOR OPERATING LICENSE, AND HOLDERS OF CONSTRUCTION PERMITS FOR BOILING WATER REACTORS

Gentlemen:

SUBJECT: INSPECTIONS OF BWR STAINLESS STEEL PIPING (Generic Letter 84-11)

Inspections conducted at several boiling water reactors (BWRs) revealed intergranular stress corrosion cracking (IGSCC) in large-diameter recirculation and residual heat removal piping. These inspections were conducted pursuant to IE Bulletins 82-03, Revision 1 and 83-02, and the NRC August 26, 1983 Orders. The Commission believes that the results of these inspections mandate an ongoing program for similar reinspections at all operating BWRs. Where IGSCC is discovered, repairs, analysis and additional surveillance may also be required to ensure the continued integrity of affected pipes.

Staff efforts to date on this issue include review of the Electric Power Research Institute (EPRI) report dated August 4, 1983, establishment of a pipe crack study group within the staff, evaluation of the results of IGSCC inspections already conducted, and discussions with licensees and industry groups. As a result of these considerations, the staff has concluded that the following actions would be considered an acceptable response to the current IGSCC concerns:

1. A reinspection program of piping susceptible to IGSCC should be undertaken. The reinspection should commence within about two calendar years, adjusted to coincide with the next scheduled outage, from the previous inspection performed under IE Bulletins 82-03, 83-02, or our August 26, 1983 Order.

2. These reinspections should include the following stainless steel welds, susceptible to IGSCC, in piping equal to or greater than 4" in diameter, in systems operating over 200°F, that are part of or connected to the reactor coolant pressure boundary, out to the second isolation valve as follows.

   (a) Inspection of 20% of the welds in each pipe size of IGSCC sensitive welds not inspected previously (but no less than 4 welds) and reinspection of 20% of the welds in each pipe size inspected previously (but not less than 2 welds) and found not to be cracked. This sample should be selected primarily from weld locations shown by experience to have the highest propensity for cracking.

   (b) All unrepaired cracked welds.

   (c) Inspection of all weld overlays on welds where circumferential cracks longer than 10% of circumference were measured. Disposition of any findings will be reviewed on a case-by-case basis. Criteria for operation beyond one cycle with overlaid joints are under development.

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(d) Inspection of any weld treated by induction heating stress improvement which has not been post treatment UT acceptance tested.

(e) In the event new cracks or significant growth of old cracks* are found, the inspection scope should be expanded in accordance with IEB 83-02.

NOTE: [Results of inspections conducted to date under IEB 82-03 and 83-02 indicate that all stainless steel piping welds in systems operating over 200°F are susceptible to IGSCC. In addition, field data shows that the cracking experience does not correlate well with the Stress Rule Index (SRI) and the carbon content. Therefore, the primary index for sample selection should be field experience, where other factors such as weld preparation, excessive grinding, extensive repairs, or high stress locations are known to exist, they should also be considered in the sample selection.]

3. All level 2 and level 3 UT examiners should demonstrate competence in accordance with IEB 83-02 and level 1 examiners should demonstrate field performance capability.

4. Leak detection and leakage limits should be sufficiently restrictive to ensure timely investigation of unidentified leakage. See Attachment 1.

5. For crack evaluation and repair criteria see Attachment 2.

Accordingly, pursuant to 10 CFR 50.54(f), BWR operating reactor licensees and applicants for an operating license (this letter is for information only for those utilities that have not applied for an operating license) are requested, in order to determine whether your license should be modified or suspended, to furnish, under oath or affirmation, no later than 45 days from the date of this letter, your current plans relative to inspections for IGSCC and interim leakage detection. Your response should indicate whether you intend to follow the above staff recommended actions or to propose an alternative approach to resolving IGSCC concerns. In either case, your response should address:

(a) Scope and schedule of planned inspections

(b) Availability and qualification of examiners

(c) Description of any special surveillance measures, in effect or proposed, for primary system leak detection, beyond those measures already required by your Technical Specifications

(d) Results of the Bulletin inspections not previously submitted to NRC

(e) Remedial measures, if any, to be taken when cracks are discovered

*Significant growth of the old crack is defined as growth to a new crack size that cannot be accepted without repair for the remaining period of the current or a new cycle of operation, in accordance with Attachment 2.

The staff considers the IGSCC problem to be generic for all BWRs. Therefore, your response may incorporate by reference materials furnished by an Owners' Group. To the extent practicable, Owners' Group and EPRI participation in the IGSCC effort is encouraged.

Licensees and applicants may request an extension of time for submittals of the required information. Such a request must set forth a proposed schedule and justification for the delay. Such a request shall be directed to the Director, Division of Licensing, NRR. Any such request must be submitted no later than 15 days from the date of this letter.

This request for information was approved by the Office of Management and Budget under clearance number 3150-0011 which expires April 30, 1985. Comments on burden and duplication may be directed to the Office of Management and Budget, Reports Management Room 3208, New Executive Office Building, Washington, D. C. 20503.

Darrell G. Eisenhut, Director
Division of Licensing

Attachment. See Jacket

ATTACHMENT 1

LEAK DETECTION AND LEAKAGE LIMITS

The reactor coolant leakage detection systems are operated in accordance with the Technical Specification requirements to assure the discovery of unidentified leakage that may be caused by throughwall cracks developed in austenitic stainless steel piping.

A. The leakage detection system shall be sufficiently sensitive to detect and measure small leaks in a timely manner and to identify the leakage sources within practical limits. Particular attention should be given to upgrading and calibrating those leak detection systems that will provide prompt indication of an increase in leakage rates

   Other equivalent and/or local leakage detection and collection systems will be reviewed on a case-by-case basis.

B. Plant shutdown shall be initiated for inspection and corrective action when any leakage detection system indicates, within any period of 24 hours, an increase in rate of unidentified leakage in excess of 2 gpm or its equivalent, whichever occurs first. For sump level monitoring systems with a fixed-measurement interval method, the level shall be monitored at 4-hour intervals or less.

C. At least one of the leakage measurement instruments associated with each sump shall be operable, and the outage time for inoperable instruments shall be limited to 24 hours or immediately initiate an orderly shutdown.

D. Unidentified leakage should include all leakage other than

(1) leakage into closed systems, such as pump seal or valve packing leaks that are captured, flow metered, and conducted to a sump or collecting tank, or

(2) leakage into the containment atmosphere from sources that are both specifically located and known either not to interfere with the operations of unidentified leakage monitoring systems, or not to be from a through-wall crack in the piping within the reactor coolant pressure boundary.

E. A visual examination for leakage of the reactor coolant piping shall be performed during each plant outage in which the containment is deinerted. The examination will be performed consistent with the requirements of IWA-5241 and IWA-5242 of the 1980 Edition of Section XI of the ASME Boiler and Vessel Code. The system boundary subject to this examination shall be in accordance with IWA-5221.

ATTACHMENT 2

CRACK EVALUATION AND REPAIR CRITERIA

1. Background

(a) Code Requirements

The ASME Boiler and Pressure Vessel Code Section XI has rules for evaluating the acceptability of flaws for further operation. Table IWB 3514-3 provides rules for acceptability of flaws without further evaluation; although the specific dimensions of such acceptable flaws depends on both the length and depth of the flaws, the practical effect is that flaws less than about 10% of the wall thickness are acceptable for further operation without analysis or repair.

A new section has recently been added to the Code, IWB 3600. This extends the Code flaw evaluation rules for piping to include specific rules whereby flaws deeper than those allowed by IWB 3514-3 can be accepted for further operation without repair.

Section IWB 3600 also requires that these acceptable flaw sizes include considerations of crack growth by stress corrosion and fatigue. In other words, if a crack is to be considered acceptable for further operation without repair, it must be shown that it will not grow to be larger than the IWB 3640 limits during the time period for which the evaluation is performed.

(b) Crack Growth Assessment

IGSCC at welds in BWRs is primarily initiated by very high tensile residual welding stresses on the inside surface at the heat affected (sensitized) zones of the base metal very near the welds. This tensile residual stress changes to a compressive stress toward the middle of the pipe wall; this reduction in stress reduces the crack growth rate through the center portion of its pipe wall. As the crack progresses further through the wall, the relative effect of the pressure and bending stresses increases, and the crack growth rate will increase.

The residual stress patterns and calculational methods for crack growth rates are fairly well established by considerable research and correlations with service experience. The staff has selected parameters that should lead to overprediction of growth. This is intended to compensate for uncertainties discussed in more detail below.

(c) Staff Treatment of Uncertainties

One of the main uncertainties associated with the evaluation of pipe cracks is the uncertainty of crack sizing, both depth and length of IGSCC cracks. Although this technology is being improved, the uncertaintiy in crack sizing will likely remain.

The staff has used a relatively simple approach to cover sizing uncertainties. In practice, the staff approach permits operation of unrepaired cracks but only if calculations show that they would not exceed Code limits even if the crack at the start of operation were actually twice as large as reported.

2. Staff Acceptance Criteria

(a) Criterion for Operation without Repair

Plant operation is permitted with cracked welds only for the time period that the cracks are evaluated to not exceed 2/3* of the limits for depth and length provided in ASME Code Section XI, Paragraph IWB-3640. Crack growth analyses must include any additional stress imposed on the weld by other weld repair operations, and each analysis must be approved by the NRC.

(b) Criteria for Cracked Repairs

(i) If cracked welds are repaired by weld overlay, the thickness of the overlay must be sufficient to provide full IWB-3640 margin during the proposed operating period, assuming that the cracks are or will grow completely through the original pipe wall and the first overlay layer to the low carbon and low ferrite portion of the overlay, unless it is demonstrated that the crack(s) are shallow enough to be arrested by the weld overlay.

*This criterion allows for an uncertainity of up to 100% in crack depth sizing for reported cracks up to 25% of wall thickness.

Effective overlay thickness is defined as the thickness of overlay deposited after the first weld layer that clears dye-penetrant testing (PT) inspection.

(ii) The minimum effective overlay thickness permitted, even for very short cracks in either longitudinal or circumferential direction, is two weld layers after the first layer to clear PT inspection.

(iii) Full structural strength weld overlays must be provided for long cracks with total circumferential extent approaching the length that would cause limit load failure if they were actually through-wall.

(iv) Multiple short circumferential cracks are to be treated as one crack with a length equal to the sum of the circumferential lengths.

3. Discussion of Staff Acceptance Criteria

Since the period of operation between inspections could vary from plant to plant and the applied stress level varies from location to location, use of a fixed simplified repair criterion established on the bases of crack size prior to the period of operation would be difficult. In any case, however, flaws less than about 10% of the wall thickness are acceptable for further operation without repairs. For a typical 18 month operating cycle, the staff criteria would generally require that

cracks greater than 30% of the circumference and cracks with reported depth of 25% or greater of the thickness will likely need some form of repair. For the same 18 month cycle, cracks of smaller size down to 10% of wall thickness may be acceptable without repair but would require evaluation in accordance with the staff criteria.