SSINS No.: 6820
OMB No.: 3150-0096
Expiration Date: 12/31/84
IEB 83-02

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

March 4, 1983

IE BULLETIN NO. 83-02: STRESS CORROSION CRACKING IN LARGE-DIAMETER STAINLESS STEEL RECIRCULATION SYSTEM PIPING AT BWR PLANTS

Addressees:

Those licensees of operating boiling water reactors (BWRs) identified in Table 1 for action. All other licensees and holders of construction permits (CPs) for information only.

Purpose:

IE Bulletin 83-02 is issued to further inform all licensees and CP holders about the recent generic pipe cracking problems involving BWR plants and to require actions of those licensees listed in Table 1.

Description of Circumstances:

As a result of the extensive intergranular stress corrosion cracking (IGSCC) found at Nine Mile Point Unit 1, the NRC issued IE Bulletin 82-03, Revision 1 for action to nine BWR plants scheduled for refueling outages in late 1982 and early 1983. Inspections pursuant to IEB 82-03, Revision 1, and NUREG-0313, Revision 1, have shown cracking of the main recirculation system piping in five of seven plants examined to date. Table 2 presents a summary of affected plants based on information available to date. IEB 82-03 Rev.1 discusses the IGSCC problems experienced at Nine Mile Point Unit 1. A brief description of the cracking problems at Browns Ferry Unit 2, Monticello and Hatch Unit 1 is presented below.

At Browns Ferry Unit 2, the inservice inspection (ISI) was extended to include the welds joining the jet pump piping sweepolets to the manifold of both A and B loops. Unacceptable indications were found in the heat-affected zone of the manifold in the loops A and B sweepolet-to-manifold joint nearest the end caps. All of the indications were interpreted to be cracks near the inside surface and were determined by UT to be about 1¼ inches long (roughly parallel to the weld), and of about 20 percent depth through-wall. As a result of further design analysis, review of shop fabrication records, and supporting in-situ metallography and ferrite determinations, the licensee established that the affected weld was solution heat treated and, therefore, not subject to the IGSCC. The licensee believes the cracking may be due to fatigue from flow-induced vibration. At this time the licensee is trying to resolve the problem.

At Monticello, IGSCC was confirmed in one end-cap-to-pipe weld of the 22-inch-diameter distribution header (manifold) and at five welds in the jet pump inlet piping safe-ends which are 12 inches in diameter and are made of schedule 80 stainless steel. The cracks initiated on the inside surface in heat affected zones (HAZs) of the welds. Some cracks were oriented axially and some circumferentially. They varied from ¼ inch to 1 inch in length. Some axial cracks in the recirculation inlet risers were found to be through-wall during subsequent repair activities and hydrotesting, although ultrasonic examination previously performed on these welds did not reflect this condition.

At Hatch Unit 1, multiple linear indications characteristic of the IGSCC found at Monticello were identified at seven welds in the large-diameter recirculation and associated residual heat removal (RHR) piping. The affected welds were located as follows: All four 22-inch-diameter manifold end-caps, one 22-inch-diameter branch connection (sweepolet-to-manifold) of the recirculation piping, one elbow-to-pipe weld in the 20-inch RHR piping, and one pipe-to-pipe weld in the 24-inch diameter RHR piping. The location and orientation of the indications were very similar to those found at Monticello. The length of the indications ranged up to ½ inch in the axial direction and 1½-inch in the circumferential direction. Based on UT measurements, the depth of axial component of the crack indications were found to have essentially penetrated through the wall in three of the four end-cap welds repaired to date.

The discovery of extensive IGSCC in the large-diameter recirculation piping at Nine Mile Point Unit 1 (NMP 1) after a decade of acceptable service has resulted in increased concern about the effectiveness of UT methodology used in the inservice inspection of stainless steel BWR pipe welds, particularly in large-diameter piping. Therefore, the goal of Item 1 of IEB 82-03, Revision 1 was to obtain reassurance of the capability of UT inspection systems, techniques, and operators to detect significant IGSCC problems in the nine BWR plants that were performing ISI during fall/winter outages. The performance test protocol as stated in Item 1 of IEB 82-03, Revision 1 required the licensee and/or ISI agencies to demonstrate their capability to detect IGSCC in large-diameter recirculation system piping before resuming power operation. Within this context, Electric Power Research Institute's NDE (EPRI-NDE) Center arranged to have five reasonably characterized, service-induced cracked pipe samples from the NMP 1 plant available at Battelle Columbus Laboratories (BCL) for industry performance capability demonstrations (PCDs).

All nine plants have now satisfied the demonstration phase of IEB 82-03, Revision 1. By letter dated January 28, 1983, EPRI provided each licensee a summary of all teams performances, based on composite results from the five samples, plus a key to identify their ISI team's achievement.

The PCD results at BCL have shown that excellent performance can be achieved by well trained and experienced personnel with appropriate procedures and evaluation methods. However, personnel from a relatively few licensee/ISI organizations achieved this level of competence during the first qualification attempt. The overall results revealed a high failure rate which required retesting of the licensee/ISI organization teams. Several interrelated factors contributed to this rate of failure:

1. UT procedures essentially meeting only the minimum requirements of the ASME Section XI code were ineffective.

2. UT procedures lacked specific detailed guidance on UT systems and methods proven capable of detecting IGSCC in thick-walled piping.

3. Some UT operators were inexperienced in evaluating signal patterns of reflectors in thick-walled, large-diameter piping. Thus, some cracks were missed, or were called geometry effects; some geometry effects were falsely called cracks.

4. Many UT operators, inexperienced about the nature of IGSCC in large-diameter piping, did not establish finite metal path calculations during scanning; this resulted in falsely identified conditions.

In view of the collective results at BCL, a continuation of the PCD program appears necessary. Accordingly, the EPRI-NDE Center has arranged to have a series of service-induced cracked specimens available for this purpose at their facility about March 14, 1983.

The NRC recognizes that the prescribed actions of this bulletin exceed present plant ISI surveillance requirements under ASME Code Section XI rules. However, in view of the apparently generic pipe cracking experience and results of the UT demonstration trials, the NRC believes such an augmented ISI plan is necessary to reasonably assure the integrity of the recirculation system for continued operations. These actions are intended to apply only to the currently scheduled refueling outage for those plants listed in Table 1. Any licensee who finds these actions will significantly impact the duration of the refueling outage may request relief by written request to the appropriate NRC regional office. Such requests must address (1) the impact on the length of the outage, (2) proposed alternative actions, and (3) technical basis for continuing operation.

Actions to Be Taken by Licensees of BWR Facilities Identified in Table 1:

1. Before resuming power operations following this scheduled or extended outage, the licensee is requested to demonstrate the effectiveness of the detection capability of the UT methodology planned to be used to examine welds in recircirculation system piping. It is intended that the demonstrations be performed at the EPRI-NDE Center on service-induced cracked pipe samples made available for this purpose. Each licensee should assure that the demonstration is valid for the weldments of the recirculation system piping of their plant. Arrangements should be made to facilitate NRC witnessing of these tests. The demonstration tests will employ the following criteria.

   a. Ultrasonic Testing System: To ensure that the field UT system will respond in the same way as the demonstrated system, the same procedures, standards, make and model of the UT instrument, and transducers to be utilized in the plant ISI are to be used in the IGSCC detection capability demonstration.

b. Personnel Performing Demonstration: UT personnel teams drawn from the licensee/ISI contractor who will be actually supervising, performing examinations, recording data, and evaluating indications at the plant site will participate in the performance demonstration tests. All members of the teams must participate directly in the UT scanning, data recording, and evaluation of the test samples. To ensure completion of testing within the time constraints below, the team should be limited to six persons. For subsequent plant inspections, the personnel/equipment requirements noted below will apply.

c. Pipe Samples: The total number of pipe samples selected should constitute an equivalent of 120 inches of weld for the demonstration tests.

d. Acceptable Criteria: Eighty percent of the total number of preselected cracks in the sample control group must be called correctly to constitute an acceptable test. Excessive false call rates may result in an unacceptable performance rating.

e. Demonstration Time Limit: ALARA radiation dose considerations place constraints upon the time spent in field inservice inspection of a weld. Therefore, a time limit of six hours, not including equipment calibration time, will be imposed for the examination and data recording. Completion of data evaluation and preparation of final results of individual licensee/ISI contractors should take no longer than one additional working day.

f. Review of UT Procedures: The specific procedure(s) to be used by the licensee/ISI contractor(s) for plant inservice inspection is to be made available for review as part of the demonstration activity. It is expected that the UT procedure and equipment system will have been validated to be capable of detecting IGSCC by the licensee/ISI contractor before initiating the scheduled demonstration activities.

NOTE: Some of the licensees listed in Table 1 have completed efforts to validate the UT detection capability to be used to perform plant inspections in accordance with the requirements of Action Item I of IEB 82-03, Revision 1. These licensees need not repeat this effort in accordance with Action Item 1 of this bulletin provided that: the previous validated inspection group performs the new plant examination using identical UT procedures, standards, make and model of UT instrument, and the same make and model transducers that were used to complete the previous validation effort. In addition, the UT personnel employed in the new examination must be the same; or those having appropriate training (documented) in IGSCC inspection using cracked thick-wall pipe specimens, and are under direct supervision of the Level II/III UT operators who successfully complete the performance demonstration tests.

2. Before resuming power operations licensees are to augment their ISI programs to include an ultrasonic examination of the following minimum number of recirculation system welds:*

   a. Ten welds in recirculation piping of 20-inch diameter, or larger.

   b. Ten welds of the jet pumps inlet riser piping and associated safe-ends.

   c. Two sweepolet-to-header (manifold) welds of jet pump risers nearest the end caps, if applicable to the design.

   If flaws indicative of cracking are found in the above examination, additional inspection is to be conducted in accordance with IWB 2430 of ASME Code Section XI.

3. Before resuming power operations following the outage, the licensee is to report the results of the Item 2 inspection and any corrective actions (in the event cracking is identified). This report should also include the susceptibility matrix used as a basis for welds selected for examination (e.g. stress rule index, carbon content, high stress location, repair history) and their values for each weld examined.

4. The NRC has an on-going program to evaluate possible additional longer-term requirements relative to the IGSCC problem in the BWR recirculation system piping. The NRC may need additional information as part of this program. Therefore, licensees are requested to retain the records and data developed pursuant to the inspections performed in accordance with Item 2.

5. The written report required by Item 3 shall be submitted to the appropriate Regional Administrator under oath or affirmation under provisions of Section 182a, Atomic Energy Act of 1954, as amended. The original copy of the cover letter and a copy of the reports shall be transmitted to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555 for reproduction and distribution.

This request for information was approved by the Office of Management and Budget under clearance number 3150-0096 which expires 12/31/84. Comments on burden and duplication should be directed to the Office of Management and Budget, Reports Management, Room 3208, New Executive Office Building, Washington, D. C. 20503.

*Since Big Rock Point and LaCrosse do not have jet pumps, the licensees of these plants should provide an equivalent sampling of the recirculation piping system based on the plant design.

Although no specific request or requirement is intended, the following information would help the NRC evaluate the cost of implementing this bulletin:

- Staff time to perform requested demonstration.
- Staff time to prepare written responses.
- The occupational radiation exposure experienced.

If you have any questions regarding this matter, please contact the Regional Administrator of the appropriate NRC Regional Office or one of the technical contacts listed below.

Richard C. DeYoung, Director
Office of Inspection and Enforcement

Technical Contact: William J. Collins, IE
492-7275
Warren Hazelton, NRR
492-8075

Attachments:
1. Table 1
2. Table 2
3. List of Recently Issued IE Bulletins

Table 1

BWR Plants Scheduled to be in the
Next Refueling Mode or Extended Outage
After January 31, 1983

LICENSEE	PLANT	RELOAD DATE
Philadelphia Electric Co.	Peach Bottom Unit 3	February 1983
Vermont Yankee Nuclear Power Company	Vermont Yankee	March 1983
Tennessee Valley Authority	Browns Ferry Unit 1	March 1983
Nebraska Public Power District	Cooper	April 1983
Georgia Power Co.	Hatch Unit 2	April 1983
Consumers Power Co.	Big Rock Point	May 1983
Power Authority of the State of New York	FitzPatrick	May 1983
Commonwealth Edison Co.	Quad Cities Unit 2	August 1983
Tennessee Valley Authority	Browns Ferry Unit 3	September 1983
Carolina Power & Light Co.	Brunswick Unit 2	September 1983
Dairyland Power Corp.	LaCrosse	October 1983
Philadelphia Electric Co.	Peach Bottom Unit 2	October 1983
Commonwealth Edison Co.	Dresden Unit 3	October 1983
Boston Edison Co.	Pilgrim Unit 1	January 1984

TABLE 2

CRACK INDICATIONS IN BWR RECIRCULATED SYSTEM PIPING

PLANT	PIPE SIZE	WELD LOCATION	HOW DETECTED
NMP 1*	28" Dia.	Pipe to safe ends	Initial crack-visual Visual leakage
	28" Dia.	Pipe to Pipe	UT
	28" Dia.	Pipe to pump casing	Visual - UT
Monticello	12" Dia.	Riser to Safe End	Leakage (weepage)
	12" Dia.	Riser to Safe End	Weepage - UT
	12" Dia.	Riser to Safe End	Weepage - UT
	12" Dia.	Riser Elbow to Pipe	UT
	22" Dia.	Manifold End Cap	UT
	12" Dia.	Elbow to Pipe	Leakage (weepage) During Hydrotest-visual
Hatch	20" Dia.	Elbow to Pipe (RHR)	UT
	22" Dia.	Manifold End Cap	UT
	22" Dia.	Manifold End Cap	UT
	22" Dia.	Manifold End Cap	UT
	22" Dia.	Manifold End Cap	UT
	24" Dia.	Pipe to Pipe (RHR)	UT
	22" Dia.	12" Riser Sweepolet to Manifold	UT
Browns Ferry	22" Dia.	12" Riser Sweepolet to Manifold	UT
	22" Dia.	12" Riser Sweepolet to Manifold	UT
Brunswick	28" Dia.	Elbow to Pipe	UT
	12" Dia.	Riser to Safe End	Leakage (weepage)
	12" Dia.	Riser to Safe End	Leakage (weepage)
Dresden 2	28" Dia.	Pipe to Safe End	UT
	12" Dia.	Riser Pipe to Elbow	UT

Footnotes:

* Cracks were found in 90% of welds examined

** Generally, there were indications of more than one axial or circumferential aligned crack in each affected weld.

Attachment 3
IEB 83-02
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LIST OF RECENTLY ISSUED IE BULLETINS

Bulletin No.	Subject	Date of Issue	Issued to
83-01	Failure of Reactor Trip Breakers (Westinghouse DB-50) to Open on Automatic Trip Signal	02/25/83	All PWR facilities holding an OL and other power reactor facilities for information
82-04	Deficiencies in Primary Containment Electrical Penetration Assemblies	12/03/82	All power reactor facilities holding an OL or CP
82-03 Rev. 1	Stress Corrosion Cracking in Thick-Wall Large-Diameter Stainless Steel, Recirculation System Piping at BWR Plants	10/28/82	Operating BWRs in Table 1 for action and other OLs and CPs for information
82-03	Stress Corrosion Cracking in Thick-Wall Large-Diameter, Stainless Steel, Recirculation System Piping at BWR Plants	10/14/82	Operating BWRs in Table 1 for action and other OLs and CPs for information
82-01 Rev 1, Supp 1	Alteration of Radiographs of Welds in Piping Subassemblies	08/18/82	All power reactor facilities with an OL or CP
82-02	Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR plants	06/02/82	All PWR facilities with an OL for action and all other OLs or CPs for information
82-01 Rev. 1	Alteration of Radiographs of Welds in Piping Subassemblies	05/07/82	All power reactor facilities with an OL or CP
82-01	Alteration of Radiographs of Welds in Piping Subassemblies	03/31/82	The Table 1 facilities for action and to all others for information
81-02 Supplement 1	Failure of Gate Type Valves to Close against Differential Pressure	08/18/81	All power reactor facilities with an OL or CP

OL = Operating License
CP = Construction Permit