UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

July 25, 1994

NRC GENERIC LETTER 94-03: INTERGRANULAR STRESS CORROSION CRACKING OF CORE SHROUDS IN BOILING WATER REACTORS

Addressees

All holders of operating licenses or construction permits for boiling water reactors (BWRs) except for Big Rock Point, which does not have a core shroud.

Purpose

The purpose of this Generic Letter is to request that each addressee: (1) inspect the core shrouds in their BWR plants no later than the next scheduled refueling outage, and perform an appropriate evaluation and/or repair based on the results of the inspection; and (2) perform a safety analysis supporting continued operation of the facility until inspections are conducted.

Background

Intergranular stress corrosion cracking (IGSCC) of BWR internal components has been identified as a technical issue of concern by both the NRC staff and the industry. The core shroud is among the list of internals susceptible to IGSCC. Identification of cracking at the circumferential beltline region welds in several plants during 1993 led to the publication of NRC Information Notice (IN) 93-79, issued on September 30, 1993. Several licensees have recently inspected their core shrouds during Spring 1994 planned outages and have identified extensive cracking at the circumferential welds. These inspection findings are causing the NRC staff and industry to re-evaluate the significance of this issue. Due to the 360° degree extent of the cracking, and the location at a lower elevation where extensive cracking had not been previously observed (e.g., H5 in the attached figures), the inspections and analyses performed for Dresden Unit 3 and Quad Cities Unit 1 (Ref. 1, 2) are especially noteworthy. NRC has issued IN 94-42 on June 7, 1994, and Supplement 1 to IN 94-42 on July 19, 1994, on cracking in the lower region of the core shroud found at Dresden Unit 3 and Quad Cities Unit 1. In addition to the core shroud, NRC has an overall concern with cracking of BWR internals and encourages licensees to work closely with the BWR Owners Group (BWROG) on coordination of inspections, evaluations and repair options for internals cracking.

Discussion

EVALUATION OF RECENT INSPECTION EXPERIENCE

By letter dated April 5, 1994 (Ref. 3), the BWROG submitted to NRC generic guidance on the evaluation of BWR core shrouds. This guidance included an inspection strategy that was based on examination of the results of plant inspections up to that time. This inspection strategy was founded on IGSCC susceptibility rankings and involved focusing the examinations on the upper shroud welds (e.g., H2, H3). Enhanced visual (VT-1) or ultrasonic (UT) methods of portions of the upper shroud welds were recommended for the initial examinations. However, in light of the recent inspections at Dresden 3 and Quad Cities 1, the BWROG is re-evaluating the applicability of the inspection guidance. Cracking extending 360° around the shroud circumference was observed at the H5 weld location at both Dresden 3 and Quad Cities 1. Extensive cracking at this location had not been observed previously and would not have been expected based on the BWROG guidance. As all BWR plants have not performed inspections of their core shrouds, and since the core shroud cracking phenomenon is dependent on operating time and plant specific conditions, additional inspections are necessary to verify that conditions potentially worse than those already identified do not exist at other plants and that appropriate corrective actions are taken.

SIGNIFICANT PARAMETERS AFFECTING CORE SHROUD CRACKING

The BWROG has also previously discussed the significant parameters known to affect the susceptibility of core shrouds to IGSCC (Ref. 3). These parameters include, but are not necessarily limited to materials, fabrication and residual stresses, water chemistry, and fluence. Within and among these broad categorizations, there exists sufficient variability to make an accurate prediction of IGSCC susceptibility difficult on a generic basis. While the NRC recognizes the usefulness of these categorizations, susceptibility to cracking, or lack thereof, needs to be demonstrated on a plant-specific basis.

SIGNIFICANCE OF PART THROUGH-WALL 360° CRACKING

NRC has assessed the safety significance of part through-wall 360° core shroud cracking and has concluded that, for the most significant cracks found to date (up to 360° circumferential extent), the structural margins required by the ASME Boiler and Pressure Vessel Code pursuant to Section 50.55a of Title 10 of the Code of Federal Regulations [10 CFR 50.55a(g)] were maintained, thereby providing assurance that the shrouds would have remained intact even under postulated accident conditions. The ASME Code, Section XI, Subarticle IWB-2500, categories B-N-1 and B-N-2 specify examination and acceptance requirements for reactor internals and core support structures, including the core shroud. Paragraph IWB-3520 is referenced as the acceptance standard for integrally welded core support structures and reactor interior attachments.

By letter dated July 13, 1994 (Ref. 4), the BWROG submitted a response to previous NRC staff questions regarding the susceptibility of BWRs to safety-significant shroud cracks. In this response, the BWROG provided an evaluation

of the cracking that has been observed in plants which have inspected their shrouds. The plants which have experienced the most extensive cracking have operated for longer than 8 years and had moderate to high coolant conductivity over the first 5 cycles of operation. The BWROG evaluation indicates that the structural margins for plants most susceptible to cracking would be maintained for at least one more cycle of additional operation at current conductivity levels. However, the BWROG notes that the uncertainties in the assumptions lead to the conclusion that while development of cracks that would not satisfy the ASME Code factors of safety is unlikely, such an occurrence cannot be ruled out. Part of the purpose of this generic letter is to ascertain the likelihood of such an occurrence for each BWR plant and to take appropriate corrective action(s).

SAFETY SIGNIFICANCE OF POSTULATED ACCIDENTS WITH 360° THROUGH-WALL CRACKS

In order to assess the significance of potential cracking worse than that observed to date, NRC has evaluated the safety implications of a postulated 360° circumferential separation of the shroud for which the ASME Code safety margins are clearly not met. Based on this evaluation, NRC has determined that 360° through-wall cracking of the core shroud may not be identified under normal operating conditions, depending on the elevation of the cracking in the shroud. At the upper shroud elevations, lifting of a separated shroud due to differential pressures in the core is resisted by only a small portion of the remaining upper shroud assembly. As such, bypass flow through the gap created by the separation is sufficient to cause a power/flow mis-match indication which should be observable to the operator during operation. At the shroud lower elevations, the deadweight of the larger portion of the upper shroud assembly can be sufficient to limit lifting of the shroud such that the bypass flow would not be sufficient to be detected.

The accident scenarios of primary concern are the main steam line break, recirculation line break and seismic events. The main concern associated with cracks in the upper shroud welds (e.g., H2, H3 in the attached figures) is the steam line break, since the lifting forces generated may be sufficient to elevate the top guide, possibly affecting lateral support of the fuel assemblies and control rod operation. The main concern associated with cracks in the lower elevations of the core shroud is the postulated recirculation line break. This is because for the lower welds (e.g., H4, H5 in the attached figures) the recirculation line break loadings, if large enough, could cause a lateral displacement or tipping of the shroud which may affect the ability to insert the control rods and may result in the opening of a crack that could allow leakage through the shroud and out through the pipe break. If this leakage were large enough, it could potentially affect the ability to maintain adequate core cooling, and could affect the ability to shut down the reactor with the standby liquid control system (SLCS).

NRC has developed a probabilistic safety perspective regarding shroud separation at the lower elevation (Ref. 4) for Dresden, Unit 3 and Quad Cities, Unit 1. The assessment estimated the potential contribution to core damage frequency due to the cracked shroud. Assuming that severe shroud cracking did exist, a large rupture of either a steam or recirculation line would have to occur to generate loads sufficiently large enough to move the

shroud. Probabilistic risk assessments categorize such ruptures to be of low probability and none has ever actually occurred at an operating nuclear plant. Therefore, the unlikely occurrence of a 360° nearly through-wall crack along with a large pipe break would be necessary to pose any incremental risk. In addition, for welds in the upper portion of the shroud, through-wall degradation should be detected during normal operation (e.g., by power/flow mis-match or noise monitoring). Finally, the shroud may not move in the most adverse manner during these events, and there is some likelihood that core cooling and reactor shutdown would be achieved with no adverse consequences.

Considering the above evaluations, NRC has made conservative estimates of the risk contribution from shroud cracking and concluded that it does not pose a high degree of risk at this time. Although immediate plant shutdown for inspections is not warranted, degradation of the core shroud is an important safety consideration warranting further evaluation. The core shroud provides the important functions of properly directing coolant flow through the core, maintaining the core geometry, and providing a refloodable volume under postulated accident conditions. The NRC staff therefore considers that 360° cracking of the shroud is a safety concern for the long term based on: (1) potentially exceeding the ASME Code structural margins if the cracks are sufficiently deep and continue to propagate during subsequent operating cycles; and (2) elimination of a layer of defense-in-depth for plant safety.

Therefore, in order to verify compliance with the structural integrity requirements of 10 CFR 50.55a and to assure that the risk associated with core shroud cracking remains low, NRC has concluded that it is appropriate for BWR licensees to implement timely inspections and/or repairs, as appropriate, at their BWR facilities.

Notwithstanding the capability to evaluate the acceptability of cracked core shrouds for continued operation, the NRC believes that for many of the operating BWRs that have core shroud materials susceptible to stress corrosion cracking, repairs or additional modifications to inhibit cracking will be necessary to assure structural integrity of the shrouds in the long term.

Requested Licensee Actions

All addressees are requested to:

1. Inspect the core shrouds in their BWR plants no later than the next scheduled refueling outage;

2. Perform a safety analysis supporting continued operation of the facility until inspections are conducted. The safety analysis should consider, but not be limited to the following factors:

   a. Details of the conditions that would influence the probability of the occurrence of cracking and rate of crack growth (e.g., material types and forms, water chemistry, fluence, carbon contents, welding materials and procedures).

b. A plant-specific assessment accounting for uncertainties in the amount of cracking, which should include but not be limited to, the following:

(1) An assessment of the shroud response to the structural loadings resulting from design basis events (e.g., steam line break, recirculation line break). If asymmetric loads can affect the shroud response, these should also be considered.

(2) An assessment of the ability of plant safety features to perform their function considering the shroud response to structural loadings (e.g., control rod insertion, ECCS injection).

3. Develop an inspection plan which addresses: (a) all shroud welds (from support attachments to the vessel to the top of the shroud) and/or provides a justification for elimination of particular welds from consideration; and (b) examination methods with appropriate consideration given to use of the best available technology and industry inspection experience (e.g., enhanced VT-1 visual inspections, optimized UT techniques). Standard methods for inspection of core support structures as specified by the ASME Code, Section XI, have been shown to be inadequate for consistent detection of IGSCC in core shrouds.

4. Develop plans for evaluation and/or repair of the core shroud.

5. Work closely with the BWROG on coordination of inspections, evaluations and repair options for all BWR internals susceptible to IGSCC.

Reporting Requirements

Pursuant to Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), each holder of an operating license for a BWR except Big Rock Point shall submit, under oath or affirmation, the following written response to this generic letter:

1. Within 30 days from the date of this generic letter:

(a) A schedule for inspection of the core shroud.

(b) A safety analysis, including a plant-specific safety assessment, as appropriate, supporting continued operation of the facility until inspections are conducted.

(c) A drawing or drawings of the core shroud configuration showing details of the core shroud geometry (e.g., support configurations for the lower core support plate and the top guide, weld locations and configurations).

(d) A history of shroud inspections for the plant should be provided addressing date, scope, methods and results, if applicable.

2. No later than 3 months prior to performing the core shroud inspections (If the inspections are scheduled to begin in less than 3 months from the receipt of this letter, the licensee should contact their NRC project manager to establish a schedule for providing the following information):

   (a) The inspection plan requested above in item 3 of Requested Actions.

   (b) Plans for evaluation and/or repair of the core shroud based on the inspection results.

3. Within 30 days from the completion of the inspection, provide the results of the inspection.

The addressee should indicate whether or not the actions requested above will be implemented in the 30 day response. If an addressee chooses not to take the requested actions, a description should be provided of any proposed alternative course of action(s), the schedule for completing the alternative course of action (if applicable), and the safety basis for determining the acceptability of the planned alternative course of action(s).

NRC recognizes that some plant(s) may have already conducted inspections and/or performed repairs. However, as the inspection scope and details of the methods employed should reflect cumulative experience to date, as appropriate, this request applies to all BWRs with the exception of Big Rock Point.

NRC is also aware that the BWROG is currently developing documents with revised inspection and flaw assessment guidelines and specifications for repair options. The response should indicate whether it is intended to follow the guidance developed for this issue by the BWROG. Reference to these and other relevant generic documents developed by the BWROG are acceptable, and encouraged, as part of the response, as long as the referenced documents have been officially submitted to NRC. However, as described previously, additional plant-specific information is required to establish the justification for continued operation.

Address these required written reports to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555, under oath or affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). In addition, submit a copy to the appropriate regional administrator.

Related Generic Communications

NRC Information Notice 94-42, Supplement 1, "Cracking In The Lower Region of the Core Shroud In Boiling Water Reactors," issued on July 19, 1994.

NRC Information Notice 94-42, "Cracking In The Lower Region of the Core Shroud In Boiling Water Reactors," issued on June 7, 1994.

NRC Information Notice 93-79, "Core Shroud Cracking at Beltline Region Welds in Boiling Water Reactors," issued on September 30, 1993.

Backfit Discussion

The actions requested in this generic letter are considered backfits in accordance with NRC procedures. These backfits are necessary to verify that the addressees are in compliance with existing requirements. Therefore, on the basis of 10 CFR 50.109(a)(4)(i), a full backfit analysis was not performed. An evaluation was performed in accordance with NRC procedures, including a statement of the objectives of and reasons for the requested actions and the basis for invoking the compliance exception. A copy of this evaluation will be made available in the public document room.

A notice of opportunity for public comment was not published in the Federal Register because of the urgent nature of the actions requested by the generic letter.

Paperwork Reduction Act Statement

The information collections contained in this request are covered by the Office of Management and Budget clearance number 3150-0011, which expires July 31, 1997. The public reporting burden for this collection of information is estimated to average 350 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needs, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records Management Branch, (T-6 F33), U.S. Nuclear Regulatory Commission, Washington, D.C., 20555, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0011), Office of Management and Budget, Washington, D.C. 20503.

Compliance with the following request for information is voluntary. The information would assist the NRC in evaluating the cost of complying with this generic letter.

(1) the licensee staff time and costs to perform requested record reviews and developing plans for inspections;

(2) the licensee staff time and costs to prepare the requested reports and documentation;

(3) the additional short-term costs incurred as a result of the inspection findings such as the cost of the corrective actions or the costs of down time; and

(4) an estimate of the additional long-term costs that will be incurred as a result of implementing commitments such as the estimated costs of conducting future inspections and repairs.

If you have any questions about this matter, please contact the technical contact listed below or the appropriate NRR project manager.

Roy P. Zimmerman
Associate Director for Projects
Office of Nuclear Reactor Regulation

Technical contact: Edwin M. Hackett, NRR
(301) 504-2751

Amy E. Cubbage, NRR
(301) 504-2875

Lead Project Manager: Donald S. Brinkman, NRR
(301) 504-1409

Attachments:
1. Figure 1 - Core Shroud Structural Confirguration
2. Figure 2 - Core Shroud Weld Locations
3. References
4. List of Recently Issued NRC Generic Letters

(2) the licensee staff time and costs to prepare the requested reports and documentation;

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original signed by
Roy P. Zimmerman
Associate Director for Projects
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Attachments:
1. Figure 1 - Core Shroud Structural Confirguration
2. Figure 2 --~~Detail of Weld Locations H5 and H6 in the Dresden, Unit 3 Core Shroud~~ Core Shroud Weld Locations
3. References
4. List of Recently Issued NRC Generic Letters

OFC	OGCB:DORS	EMCB:DE	EMCB:DE	DE:NRR	DSSA:NRR	TECH ED
NAME	TJKim	EHackett	JStrosnider	BSheron	MVirgilio	JMain
DATE	7/25/94	7/25/94	7/25/94	7/25/94	7/25/94	7/22/94

OFC	OGCB:DORS	ADT:NRR	OGCB:DORS	DORS:NRR	ADPR:NRR
NAME	JGoldberg	AThadani	BDoolittle	BGrimes	RZimmerman
DATE	7/22/94	7/25/94	7/25/94	7/25/94	7/25/94

DOCUMENT NAME: 94-03.GL

FIGURE 1

CORE SHORUD STRUCTURAL CONFIGURATION

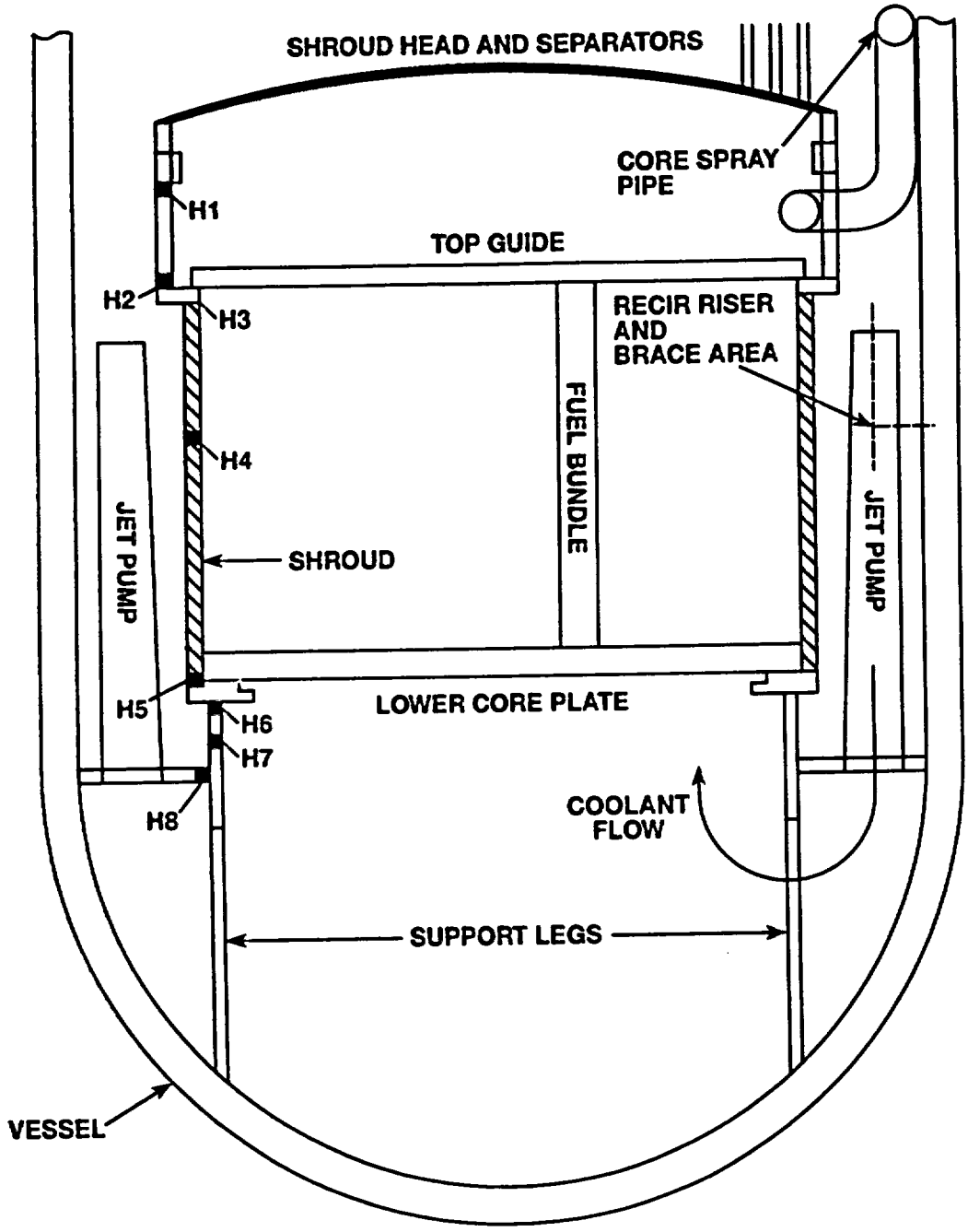
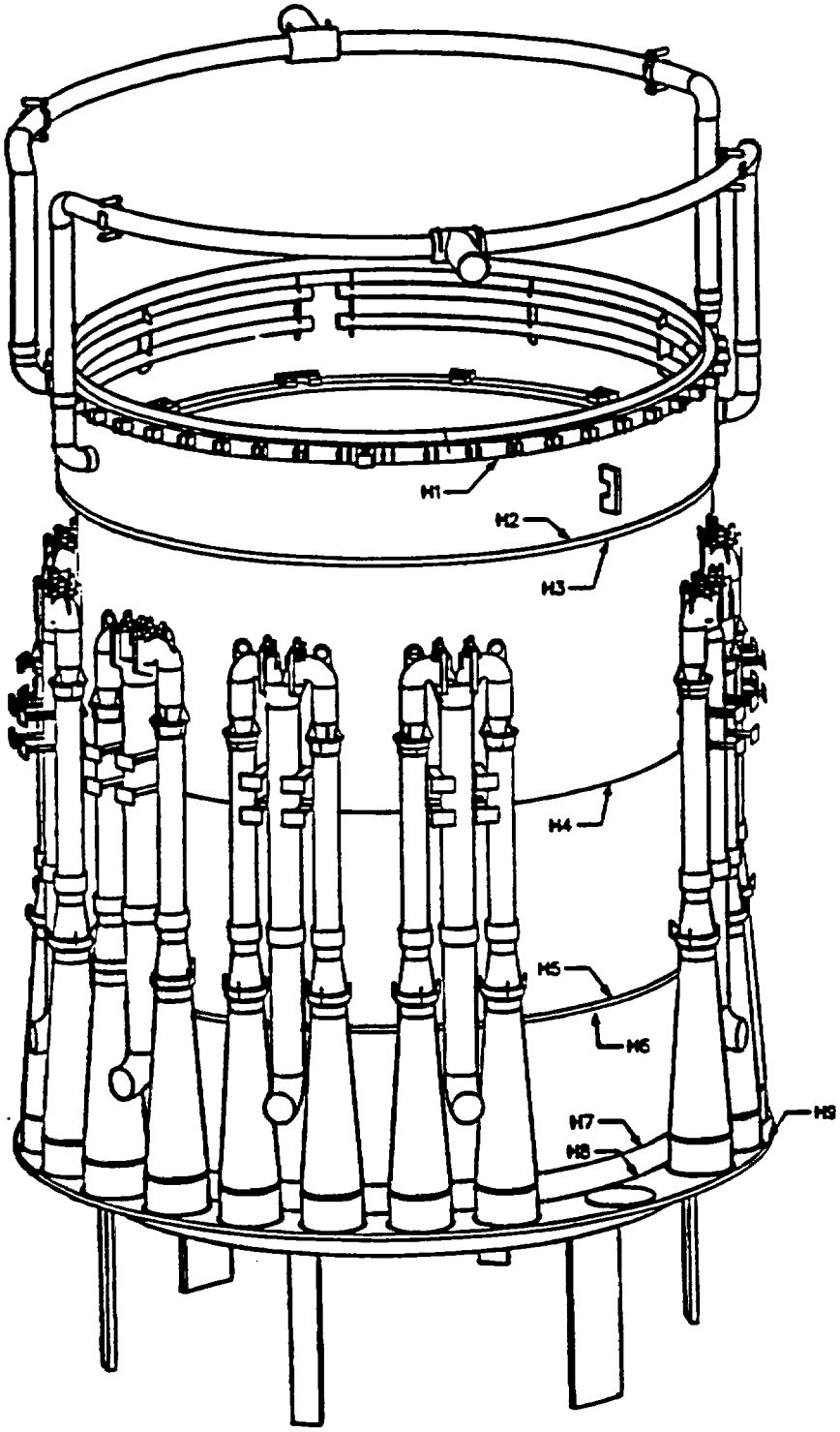


FIGURE 2
CORE SHROUD WELD LOCATIONS



References

[1] Letter from M.D. Lyster (Commonwealth Edison) to W.T. Russell (NRC), "Analytical Evaluation of Core Shroud Cracking Identified at Dresden Nuclear Power Station Unit 3, NRC Docket No. 50-249," June 13, 1994.

[2] Letter from M.D. Lyster (Commonwealth Edison) to W.T. Russell (NRC), "Analytical Evaluation of Core Shroud Cracking Identified at Quad Cities Nuclear Power Station Unit 1, NRC Docket No. 50-254," June 13, 1994.

[3] Letter from L.A. England, BWROG to USNRC, "Transmittal of BWR Core Shroud Evaluation," GE-NE-523-148-1193, April 5, 1994.

[4] Letter from R.A. Pinelli to USNRC, "Response to NRC Request for Shroud Information," GE-NE-523-A107P-0794, July 13, 1994. GE **PROPRIETARY**.

[5] NRC Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Core Shroud Cracking, Commonwealth Edison Company and Iowa-Illinois Gas and Electric Company, Dresden Nuclear Power Station, Unit 3 and Quad Cities Nuclear Power Station, Unit 1, Docket Nos. 50-249 and 50-254, July, 1994.

LIST OF RECENTLY ISSUED GENERIC LETTERS

Generic Letter	Subject	Date of Issuance	Issued To
94-02	LONG-TERM SOLUTIONS AND UPGRADE OF INTERIM OPERATING RECOMMENDATIONS FOR THERMAL-HYDRAULIC INSTABILITIES IN BOILING WATER REACTORS	07/11/94	ALL HOLDERS OF OLs FOR BOILING WATER REACTORS EXCEPT BIG ROCK POINT
94-01	REMOVAL OF ACCELERATED TESTING AND SPECIAL REPORTING REQUIREMENTS FOR EMERGENCY DIESEL GENERATORS	05/31/94	ALL HOLDERS OF OLs FOR NPRs
86-10, SUPP. 1	FIRE ENDURANCE TEST ACCEPTANCE CRITERIA FOR FIRE BARRIER SYSTEMS USED TO SEPARATE REDUNDANT SAFE SHUTDOWN TRAINS WITHIN THE SAME FIRE AREA (SUPP. 1 TO GL 86-10, "IMPLEMENTATION OF FIRE PROTECTION REQUIREMENTS")	03/25/94	ALL HOLDERS OF OLs OR CPs FOR NPRs
89-10, SUPP. 6	INFORMATION ON SCHEDULE AND GROUPING, AND STAFF RESPONSES TO ADDITIONAL PUBLIC QUESTIONS	03/08/94	ALL LICENSEES OF OPERATING NUCLEAR POWER PLANTS AND HOLDERS OF CONSTRUCTION PERMITS FOR NPRs
93-08	RELOCATION OF TECHNICAL SPECIFICATION TABLES OF OF INSTRUMENT RESPONSE TIME LIMITS	12/29/93	ALL HOLDERS OF OLs FOR NPRs
93-07	MODIFICATION OF THE TECHNICAL SPECIFICATION ADMINISTRATIVE CONTROL REQUIREMENTS FOR EMERGENCY AND SECURITY PLANS	12/28/93	ALL HOLDERS OF OLs OR CPs FOR NPRs

OL = OPERATING LICENSE
CP = CONSTRUCTION PERMIT
NPR = NUCLEAR POWER REACTORS