

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
WASHINGTON, D.C. 20555-0001

April 28, 1995

**NRC GENERIC LETTER 95-03: CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES**

Addressees

All holders of operating licenses or construction permits for pressurized water reactors (PWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter to (1) notify addressees about the recent steam generator tube inspection findings at Maine Yankee Atomic Power Station and the safety significance of these findings, (2) request that all addressees implement the actions described herein, and (3) require that all addressees submit to the NRC a written response to this generic letter regarding implementation of the requested actions.

In addition, this letter alerts addressees to the importance of performing comprehensive examinations of steam generator tubes using techniques and equipment capable of reliably detecting degradation to which the steam generator tubes may be susceptible. The performance of steam generator tube examinations is controlled, in part, by Appendix B to Part 50 of Title 10 of the Code of Federal Regulations (10 CFR Part 50).

Background

In July 1994, the licensee for Maine Yankee shut down the plant as a result of steam generator primary-to-secondary leakage. Details of the steam generator tube inspections and investigations are contained in NRC Information Notice 94-88, "Inservice Inspection Deficiencies Result in Severely Degraded Steam Generator Tubes," issued on December 23, 1994. As discussed in the information notice, inadequate eddy current test procedures since 1990, or earlier, appeared to have been the primary reason the tube degradation went undiscovered resulting in several of the tubes becoming severely degraded. In fact, with hindsight, most of the indications identified in 1994 could be traced back to at least 1990.

After approximately 6 months of operation, the licensee for Maine Yankee commenced another inspection of the steam generator tubes. The eddy current probe (i.e., a three-coil rotating pancake coil probe) and screening criteria used at the start of the outage were similar to those used during the 1994 inspections. These initial inspections resulted in the detection of a number of circumferential cracks that were larger than anticipated for the amount of time between the inspections. These results, in part, led the licensee to perform additional inspections with enhanced techniques. These enhanced

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inspections resulted in the identification of many more tubes with circumferential cracks than had previously been identified. Penetrant testing confirmed that several indications identified with the enhanced techniques were circumferential cracks. Furthermore, the destructive examination of three tubes removed from the steam generators (two with marginal responses and one with an intermediate response) confirmed that the tubes had circumferential cracks. The preliminary results from the destructive examination indicate that the three pulled tubes had maximum crack depths of 45 percent, 37 percent, and 57 percent with average depths of 24 percent, 23 percent, and 26 percent, respectively. In addition, the preliminary results indicate that the circumferential extent of these indications was underestimated during the nondestructive examination in the field.

## Discussion

### (1) Operating Experience

Both NRC and the industry have identified the reliable detection and sizing of circumferential cracks in steam generator tubes as a technical issue of concern. The detection of circumferentially oriented cracks at various locations on the steam generator tubes has resulted in the publication of several NRC information notices (90-49, 92-80, 94-05, and 94-88) and in several meetings between the NRC staff and the PWR owners groups, the industry (Electric Power Research Institute), and various licensees. The sizing of circumferential cracks has been discussed in meetings between the NRC staff and industry representatives from the Steam Generator Strategic Management Program on January 12 and February 22, 1995.

A number of factors affect the detection of circumferential cracking. These factors can be both plant specific and generic. They include, but are not limited to, the scope of the inspection, the nondestructive examination methods used for the inspection (e.g., probes, instruments, and hardware) including the plant specific factors that may affect the sensitivity of the techniques, the equipment setup for these techniques, the analysis of the nondestructive examination data, the data analyst training and performance demonstration program, and the methods used to minimize interfering signals.

Tubes with circumferential cracks are removed from service by plugging or sleeving on detection. This is due, in part, to (1) the inability to reliably size these indications, (2) the threshold of detection for circumferential indications, and (3) the inability to reliably predict crack growth rates. In addition, more data, including both laboratory and pulled-tube data, are needed to support the reliable detection and sizing of these indications.

### (2) Safety Assessment

On the basis of previous NRC studies (e.g., NUREG-0844, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes"), a safety concern which would warrant immediately shutting down plants does not exist based on probability

and risk considerations; however, since tube ruptures represent a failure of one of the principal fission product boundaries and present a pathway for primary system activity release to the environment bypassing containment, all reasonable precautions should be taken to prevent such an occurrence.

Inspection practices should furnish assurance that steam generator tube degradation will be reliably detected so that the potential for the rupturing of a tube is maintained at an acceptably low level. If licensees conclude that unexpected levels of tube degradation may exist in their steam generators, they should implement compensatory measures to minimize the chance that tube integrity is compromised and to ensure that the plant can safely respond to a tube failure. Such measures should have the objective of maintaining a safe operating posture through a defense-in-depth philosophy of (1) prevention of uncontrolled tube degradation, (2) early detection of tube degradation, and (3) mitigation of the consequences of failed tubes.

To verify compliance with regulatory requirements (10 CFR Part 50 Appendix B; technical specifications) and to maintain an appropriate degree of defense-in-depth measures, the NRC has concluded that it is appropriate for PWR licensees to take the measures enumerated in this generic letter.

#### Requested Actions

All addressees are requested to

- (1) Evaluate recent operating experience with respect to the detection and sizing of circumferential indications to determine the applicability to their plant.
- (2) On the basis of the evaluation in Item (a) above, past inspection scope and results, susceptibility to circumferential cracking, threshold of detection, expected or inferred crack growth rates, and other relevant factors, develop a safety assessment justifying continued operation until the next scheduled steam generator tube inspections are performed.
- (3) Develop plans for the next steam generator tube inspections as they pertain to the detection of circumferential cracking. The inspection plans should address, but not be limited to, scope (including sample expansion criteria, if applicable), methods, equipment, and criteria (including personnel training and qualification).

Licensees are encouraged to work closely with industry groups on coordination of inspections, evaluations, and repair options for all forms of steam generator tube degradation. In the interest of optimizing the use of resources, licensees are encouraged to develop generic safety assessments and inspection plans as described above for logical groupings of plants, where possible. Plant-specific factors that may affect the applicability of the generic assessment to a plant should be addressed (e.g., gross chemistry excursions).

**Requested Information**

All addressees are requested to submit

- (1) a safety assessment justifying continued operation that is based on the evaluations performed in accordance with Requested Actions (1) and (2) above.
- (2) a summary of the inspection plans developed in accordance with Requested Action (3) above and a schedule for the next planned inspection.

The NRC is aware that generic industry guidance with respect to performing steam generator tube inspections has been developed and is continually being updated. If the addressee intends to follow the guidance developed for this issue by the industry, reference to these and other relevant generic documents is acceptable, and encouraged, as part of the response, as long as the referenced documents have been officially submitted to the NRC. However, as described previously, additional plant-specific information may be appropriate to establish justification for continued operation.

**Required Response**

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 PWR shall submit, under oath or affirmation, the following written response to this generic letter:

- (1) Within 60 days from the date of this generic letter, all addressees are required to submit a written response
  - with the requested information if the addressee has implemented the actions requested above.
  - If an addressee has not completed or chooses not to implement the requested actions, submit a description of any proposed alternative course of action, 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.

The NRC will review the responses to this generic letter, and if concerns are identified during the review, those licensees will be notified of the NRC staff concerns.

The NRC recognizes that addressees may have already conducted inspections and/or performed safety assessments. However, as the inspection scope and details of the methods used should reflect cumulative experience to date, as appropriate, this required response applies to all PWRs.

Address the required written reports to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555-0001, under oath or affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f).

This generic letter requires submittal of information that will enable the NRC to verify that the licensee is in compliance with existing regulatory requirements (10 CFR Part 50 Appendix B; technical specifications). Accordingly, an evaluation justifying this information request is not necessary under 10 CFR 50.54(f).

#### Related Generic Communications

NRC Information Notice 94-88, "Inservice Inspection Deficiencies Result in Severely Degraded Steam Generator Tubes," December 23, 1994

NRC Information Notice 94-62, "Operational Experience on Steam Generator Tube Leaks and Tube Ruptures," August 30, 1994

NRC Information Notice 94-43, "Determination of Primary-to-Secondary Steam Generator Leak Rate," June 10, 1994

NRC Information Notice 94-05, "Potential Failure of Steam Generator Tubes Sleeved With Kinetically Welded Sleeves," January 19, 1994

NRC Information Notice 93-56, "Weaknesses in Emergency Operating Procedures Found as a Result of Steam Generator Tube Rupture," July 22, 1993

NRC Information Notice 93-52, "Draft NUREG-1477, 'Voltage-Based Interim Plugging Criteria for Steam Generator Tubes,'" July 14, 1993

NRC Information Notice 92-80, "Operation With Steam Generator Tubes Seriously Degraded," December 7, 1992

NRC Information Notice 91-67, "Problems With the Reliable Detection of Intergranular Attack (IGA) of Steam Generator Tubing," October 21, 1991

NRC Information Notice 91-43, "Recent Incidents Involving Rapid Increases in Primary-to-Secondary Leak Rate," July 5, 1991

NRC Information Notice 90-49, "Stress Corrosion Cracking in PWR Steam Generator Tubes," August 6, 1990

NRC Information Notice 88-99, "Detection and Monitoring of Sudden and/or Rapidly Increasing Primary-to-Secondary Leakage," December 20, 1988

NRC Bulletin 88-02, "Rapidly Propagating Cracks in Steam Generator Tubes," February 5, 1988

**Federal Register Notification**

A notice of opportunity for public comment was not published in the Federal Register because NRC needs licensees to submit the information requested by the generic letter in a timely manner. However, comments on the actions requested and the technical issue addressed by this generic letter may be sent to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555-0001.


**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., 20555-0001, 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 develop 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
- (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 one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

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

Technical contacts: Kenneth J. Karwoski  
(301) 415-2754

Joseph E. Donoghue  
(301) 415-1131

Lead project manager: Daniel G. McDonald  
(301) 415-1408

Attachment:  
List of Recently Issued NRC Generic Letters

*Attachment filed in Jacket*

**LIST OF RECENTLY ISSUED GENERIC LETTERS**

Generic Letter	Subject	Date of Issuance	Issued To
95-02	USE OF NUMARC/EPRI REPORT TR-102348, "GUIDELINE ON LICENSING DIGITAL UPGRADES," IN DETERMINING THE ACCEPTABILITY OF PERFORMING ANALOG-TO-DIGITAL REPLACEMENTS UNDER 10 CFR 50.59	04/26/95	ALL HOLDERS OF OLs OR CPs FOR NUCLEAR POWER REACTORS.
89-04, SUPP. 1	GUIDANCE ON DEVELOPING ACCEPTABLE INSERVICE TESTING PROGRAMS	04/04/95	ALL HOLDERS OF OLs OR CPs FOR NUCLEAR POWER REACTORS.
95-01	NRC STAFF TECHNICAL POSITION ON FIRE PROTECTION FOR FUEL CYCLE FACILITIES	01/26/95	ALL CURRENT LICENSEES & APPLICANTS FOR URANIUM CONVERSION & FUEL FABRICATION FACILITIES.
94-04	VOLUNTARY REPORTING OF ADDITIONAL OCCUPATIONAL RADIATION EXPOSURE DATA	09/02/94	ALL HOLDERS OF OLs OR CPs FOR NPRs, RADIOGRAPHY LICENSEES, FUEL PROCESSING LICENSEES, FABRICATING & REPROCESSING LICENSEES, MANUFACTURERS & DISTRIBUTORS OF BY-PRODUCT MAT'L, INDEPENDENT SPENT FUEL STORAGE INSTALLATIONS, FACILITIES FOR LAND DISPOSAL OF LOW-LEVEL WASTE, & GEOLOGIC REPOSITORIES FOR HIGH-LEVEL WASTE.
94-03	INTERGRANULAR STRESS CORROSION CRACKING OF CORE SHROUDS IN BOILING WATER	07/22/94	ALL HOLDERS OF OLs OR CPs FOR BOILING WATER REACTORS EXCEPT FOR BIG ROCK POINT, WHICH DOES NOT HAVE A CORE SHROUD.
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

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



If you have any questions about this matter, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

**Original signed by**

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

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Attachment:  
List of Recently Issued NRC Generic Letters

*Attachments filed in Jacket*

Telephone conversation between JAMitchell (EDO Staff) and RJKiessel (NRR/OECB Staff) on April 26, 1995, indicated that no comments had been received from the Commissioners. See SECY 95-100 dated 4/20/95 for additional concurrences.

DOCUMENT NAME: 95-03.GL

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OFFICE	TA:DOPS/NRR	D:DOPS/NRR	ADP:NRR	RPZ
NAME	AJKugler <i>AK</i>	BKerimes	RPZimmerman	
DATE	04/27/95	04/27/95	04/27/95	

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If you have any questions about this matter, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

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Attachment:  
List of Recently Issued NRC Generic Letters

26 *[Signature]*  
Telephone conversation between JAMitchell (EDO Staff) and RJKiessel (NRR/OECB Staff) on April 25, 1995, indicated that no comments had been received from the Commissioners. See SECY 95-100 dated 4/20/95 for additional concurrences.

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NAME	AJKugler <i>[Signature]</i>	BKGrimes <i>[Signature]</i>	RPZimmerman
DATE	04/26/95 <i>[Signature]</i>	04/26/95	04/ /95

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The Commissioners

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warrant immediately shutting down plants does not exist based on probability and risk considerations. However, prompt actions are necessary to ensure that licensees evaluate the recent operating experience and take appropriate actions.

A notice of opportunity for public comment on the proposed generic letter was not published in the Federal Register because of the urgent nature of the information requested by the generic communication. The generic letter will be published in the Federal Register when it is issued.

The proposed generic letter has not been formally reviewed and endorsed by the Committee To Review Generic Requirements (CRGR) because of its immediately effective nature. However, the proposed generic letter was discussed with CRGR during its meeting on April 11, 1995. The staff has incorporated the comments provided by CRGR at that meeting. The generic communication, as well as the appropriateness of treating it as an immediately effective generic letter, will be discussed with CRGR at its next regularly scheduled meeting.

The Office of the General Counsel reviewed this generic letter and has no legal objections.

The staff intends to issue this generic letter approximately three working days after the date of this information paper.

Original Signed by:

James M. Taylor  
Executive Director  
for Operations

James L. Milhoan *JLM*

Attachment: Proposed Generic Letter

**\*SEE PREVIOUS CONCURRENCE**

DOCUMENT NAME: G:\KARWOSKI\COMM.MEM

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Date	4/13/95		4/13/95		4/14/95		4/14/95		4/14/95	
Office	*OECB		*DOPS:D		*OGC	E	*NRR:ADPR		*NRR:ADT	
Name	RKeissel		BGrimes		JGoldberg		RZimmerman		ATHadani	
Date	4/14/95		4/14/95		4/14/95		4/18/95		4/17/95	
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