PB 275 580
NUREG-0410

excerpt

NRC PROGRAM FOR THE RESOLUTION OF GENERIC ISSUES RELATED TO NUCLEAR POWER PLANTS

Includes Plans for the Resolution of "Unresolved Safety Issues" Pursuant to Section 210 of the Energy Reorganization Act of 1974, as Amended)

Report to Congress
January 1, 1978

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72-B
17-C
3-D
133
-8 → paperwork complete
125
+4 → after TMI
129

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U. S. Nuclear Regulatory Commission

Public Hearing
Univ of Mo - St. Louis 7-B
Date 1-8-07 Case No. ER-2007-0002 ER-2002-0003
Reporter SW

REVISION 0
SEPTEMBER 23, 1977

CATEGORY A TECHNICAL ACTIVITY NO. A-3

Title: Westinghouse Steam Generator Tube Integrity

Lead Responsibility: Division of Operating Reactors

Lead Assistant Director: Darrell G. Eisenhut, Assistant Director for Operational Technology, DOR

Task Manager: Richard J. Stuart, Section Leader, Engineering Branch, DOR

1. Problem Description

Pressurized water reactor steam generator tube integrity can be degraded by corrosion induced wastage, cracking, reduction in the tube diameter (denting) and vibration induced fatigue cracks. The primary concern is the capability of degraded tubes to maintain their integrity during normal operation and under accident conditions (LOCA or a main steam line break) with adequate safety margins.

Westinghouse steam generator tubes have suffered degradation due to wastage and stress corrosion cracking. Both types of degradation have been nominally arrested; however, degradation due to denting which leads to primary side stress corrosion cracks is the major problem at present, and the principal focus of this technical activity.

2. Plan For Problem Resolution

The major portion of the NRC staff efforts related to the resolution of the denting problem will consist of evaluation of the results of investigations by Westinghouse, EPRI, and EPRI supported contractors. In addition, NRC supported technical assistance and confirmatory research programs will be used as the basis for evaluation of applicant supplied data.

The specific activities directed at resolution of the denting problem in Westinghouse steam generators consist of the following issues and tasks:

A. Generic Evaluation of ISI Results

Review and evaluate the various eddy current inspection results; i.e., experience from operating reactors and evaluate these data as they relate to the generic determination of failure probability of degraded tubes. In addition, evaluate the test programs and analytical studies to provide staff understanding sufficient to continue to provide justification for continued safe operation of operating reactors.

APPROVED BY TASC, SEPTEMBER 6, 1977
TASC COMMENTS INCORPORATED,
SEPTEMBER 23, 1977

B. Evaluation of Transients and Postulated Accidents

Evaluation of failure consequences under postulated accident conditions (LOCA and MSLB) to determine the acceptable levels of primary to secondary leakage rates and the effect on ECCS performance. The results will be used to define the acceptable number of tube failures that may be necessary as a licensing basis considering predicted fuel behavior and radiological dose during transients and postulated accident conditions.

C. Evaluation of Steam Generator Tube Structural Integrity

Review and evaluate the structural integrity of steam generator tubes under normal operating and postulated accident conditions (LOCA, SSE and MSLB) including licensee and Westinghouse analyses where appropriate to generic conclusions.

D. Establish Tube Plugging Criteria

Establish a generic tube plugging criteria that is consistent with the determined allowable leak rate, tube structural integrity and degradation rates. These results will allow assessment of the adequacy of the requirements defined in Regulatory Guide 1.121.

E. Secondary Coolant Chemistry Requirements

Evaluate the mechanism of tube degradation. The results will be used to define the requirements for secondary coolant chemistry control including considerations for condenser in-leakage.

F. Evaluation of ISI Methods

Review the development of improved eddy-current probes, coils and multi-frequency techniques to better quantify dents and growth of dents and increase sensitivity for detecting cracks in dented regions.

G. Establish Criteria for Revision of Regulatory Guide 1.83

Integrate experience from inservice inspection results, the results from the evaluation of various ISI improvements and the plugging and secondary water chemistry requirements into criterion for possible revision of Regulatory Guide 1.83.

H. Steam Generator Replacement (Prototype)

Review and evaluate plans for initial steam generator replacement as generic basis for subsequent replacement actions.

I. Review Design Criteria for Plants Not Yet Licensed

Review and evaluate design modifications proposed by applicants and Westinghouse to prevent denting in plants not yet licensed for operation.

ISI = inservice inspections

3. NRR Technical Organizations Involved

a. Engineering Branch, Division of Operating Reactors, has the primary lead responsibility for the overall review and evaluation of steam generator tube integrity. This includes operational experiences, tube failure mechanisms and potential repairs, plugging criteria, ISI requirements, tube failure probability, leakage rate limits, and secondary coolant system control. This also includes the lead responsibility for determining the probability of LOCA and MSLB initiating events and the probability of tube failures during these events and responsibility for deteriming the number of tubes assumed to fail in LOCA and MSLB analyses. The Engineering Branch also has lead responsibility for the review of prototype steam generator tube replacement.

Manpower Estimates: 0.1 manyear FY 1977, 1.0 manyear FY 1978, and 1.0 manyear FY 1979.

b. Environmental Evaluation Branch, Division of Operating Reactors, has the lead responsibility for the review and evaluation of the off site dosage related to the consequence or probability of a Main Steam Line Break (MSLB) accident or LOCA given the physical conditions determined in part a, above. EEB will also consult with EB and provide support for the probabilistic evaluation of MSLB and LOCA initiating events, the probability of tube failures during these postulated events and evaluation of environmental aspects of steam generator tube replacement.

Manpower Estimates: 0.1 manyear FY 1977, 0.2 manyear FY 1978, and 0.2 manyear FY 1979.

c. Reactor Safety Branch, Division of Operating Reactors, has the lead responsibility for the review and evaluation of: (1) the ECCS performance related to secondary-to-primary leakage as a consequence of a LOCA, and (2) the effect of primary-to-secondary leakage during a MSLB accident on fuel failures.

Manpower Estimates: 0.1 manyear FY 1977, 0.13 manyear FY 1978, and 0.13 manyear FY 1979.

d. Mechanical Engineering Branch/Materials Engineering Branch, Division of Systems Safety, has lead responsibility for the review of new design/material concepts and new system component requirements. This will apply to PWR facilities not yet licensed for operation.

4.

The activities involved will include the review and evaluation of applicant's and Westinghouse's proposed improvements on the design and/or operation of the steam generators; for items such as secondary coolant chemistry, design modifications to avoid denting, condenser design to avoid inleakage, ISI requirements, recommendation for revision of Regulatory Guides, and provisions for access opening and space in the containment to facilitate steam generator inspections.

Manpower Estimates: 0.1 manyear for FY 1977, 0.5 manyear FY 1978, 0.5 manyear 1979, and 0.5 manyear FY 1980.

e. Analysis Branch, Division of Systems Safety, has the lead responsibility in developing analytical capabilities (computer codes, etc.) to evaluate the effects of steam generator tube rupture (s) concurrent with various reactor transients that include MSLB and LOCA accidents. The purpose is to determine the equivalent number of tube failures that can be tolerated during transient events. This information will then be factored into the overall program of determining an adequate sample plan for tube inspections.

Manpower Estimates: 0.1 manyear FY 1977, 0.2 manyear FY 1978, and 0.2 manyear FY 1979.

f. Reactor Systems Branch, Division of Systems Safety. Has the responsibility of implementing new procedures on CP/OL safety analyses for plants yet to be licensed, should any be required as the results of this technical activity.

Manpower Estimates: 0.1 manyear FY 1979, 0.3 manyear FY 1980.

g. Environment Project Branch No. 1, Division of Site Safety and Environmental Analysis. Responsible for the review of the non-radiological environmental aspect of steam generator replacement for the lead unit.

Manpower Estimeates: 0.2 manyear FY 1978

4. Technical Assistance Requirements:

a. Contactor: Brookhaven National Laboratory (BNL) - DOR, DSS

Funds Required: $98K FY 1977, $200K FY 1978 and $175K FT 1979

This effort is funded as part of an overall program at BNL applicable to the three Category A Technical Activities (A-3, A-4 and A-5) related to PWR steam generators. Funding values under DORSAT are not included.

This program is needed to obtain technical consultation and assistance to review information in areas of water chemistry and corrosion analysis, monitored jointly by EB/DOR and MTEB/DSS. Stress and/or burst strength calculations are funded in part under DORSAT contract on an as-needed basis. This program will provide assistance in accomplishing Tasks 2C, 2E and 2G.

b. Contactor: Idaho National Engineering Laboratory (INEL) - DSS

Funds Required: $75K FY 1977, $100K FY 1978.

This effort is generic in nature and will be applicable to the three Category A Technical Activities (A-3, A-4 and A-5) related to PWR steam generators.

The purpose of this program is to determine the effect of steam generator tube plugging on the predicted peak clad temperatures following a postulated LOCA. The primary activity is to produce a reliable computer code to aid the evaluation of the effects of tube plugging on the ECCS performance. An addition to the program will be needed to consider steam generator tube failures concurrent with MSLB or a LOCA. This program will provide assistance in accomplishing Tasks 2B and 2D.

c. Contactor: Sandia Laboratories, DOR proposed

Funds Required: $50K FY 1977, $100K FY 1978, and $150K FY 1979.

This work is of generic nature, and will be applicable to all PWR steam generators.

A program is needed for a statistical analysis of steam generator tube failures in operating reactors in order to establish the bases for the sampling plan for inservice inspection. This is a new program to augment staff effort in steam generator safety reviews and will assist in addressing Tasks 2A, 2F and 2G.

5. Assistance Requirements from Other NRC Offices:

a. Office of Nuclear Regulatory Research, Division of Reactor Safety Research, Metallurgy and Materials Branch and Probabilistic Analysis Branch

RES has funded, at the request of NRR, a major confirmatory experimental program at Pacific Northwest Laboratory. The activity of this program consists of a series of tests to verify the burst and cyclic strengths of degraded steam generator tubes and the leakage rate data. This program is managed by Metallurgy and Materials Branch, (Task 2C).

RES has been requested to fund a new program, possibly starting this fiscal year, addressing the factors which determine Inconel 600 susceptibility to stress corrosion cracking in primary water. Metallurgical condition, chemistry, temperature, stress and environment will be considered, (Task 2E).

The Probabilistic Analysis Branch funded the program to assist EEB in probabilistic analyses, (Task 2B).

b. Office of Standards Development, Division of Engineering Standards, Structures and Components Standards Branch

. OSD has funded a confirmatory research program at Battelle Columbus laboratory to evaluate eddy current methods for inspecting steam generator tubes as a subcontract to Brookhaven National Laboratory, (Part of Task 2F).

c. Office of the Executive Director For Operations, Applied Statistic Group.

. Provide assistance to EB/DOR for statistical assessment of steam generator tube integrity, (Part of Tasks 2A, 2F, and 2G).

d. ACRS

This task is closely related to one of the generic items identified by the ACRS and, accordingly, will be coordinated with the committee as the task progresses.

6. Interactions With Outside Organizations

a. Licensee(s) of Westinghouse (W) Nuclear Facilities

At present all W plants experiencing tube denting will be monitored for the progress of denting. Each licensee will submit an analysis of the consequences of tube denting on tube integrity and demonstrate that adequate safety margins exist for continued safe operation. The Turkey Point and Surry licensees will be closely monitored relative to steam generator replacement.

b. Westinghouse

The primary interaction with Westinghouse has been and continues to be on the investigation program for the resolution of the problems at Westinghouse designed plants and their generic implication such as the licensing bases or justifications for continued operation for Westinghouse plants with known tube degradations. For interim periods of operation before the cause of denting is identified and corrective measures implemented, the interaction will be needed to ensure that Westinghouse develops and improves capabilities for the evaluation of ECCS performance under postulated accidents concurrent with tube failures, should such a licensing basis become necessary. Review and evaluate new designs proposed to prevent denting in facilities not yet licensed for opreration.

c. EPRI, PWR Owner Group etc.

Interactions with other organizations such as the Electric Power Research Institute (EPRI) and the "ad hoc" organization of PWR owners may also be required because of mutual interests in the safe operation of steam generators in general and in particular, the various problems associated with the operation of steam generators.

The purpose for interactions with these organizations is to exchange information on the research works sponsored by NRC and these outside organizations in identifying potential problems or solutions to existing problems associated with the operation of steam generators. Current programs in this area include an EPRI sponsored steam generator program in conjunction with Combustion Engineering. One aspect of this program is designed to define the mechanism of tube denting, and its goal is to provide corrosion-related information for improved steam generator coolant system technology and operation. The technology will be applied to the operation of plant systems and components that affect the reliability of steam generators. Additionally, EPRI had underway an ISI round robin test program for steam generator tubes to determine the effectiveness of various ISI techniques and methods for tube inspection.

7. Schedule for Problem Resolution

The major milestone for each program task are as follows:

Task 2A - EB/DOR, MEB & MTEB/DSS

- Review and evaluation of tube denting at W plants - June, 1979
- Monitor ISI results of PWR facilities with W steam generators - June 1979

Task 2B - EEB & RSB/DOR

- Review and evaluate the consequence of MSLB for plants relevant to determination of allowable leakage rate - June 1977
- Review and evaluate plant systems at PWR facilities with W steam generators to ensure comprehensive generic coverage as required-FY 1978, FY 1979.

Task 2C - EB/DOR, MEB/DSS

- Review and evaluate generic integrity analysis related to denting (1) short term operation - July 1977, (2) long term operation - Spring 1978
- Review RES sponsored program at PNL - June 1979

Task 2D - EB/DOR, MEB/DSS

- Recommendations for revision of Regulatory Guide 1.121 - September, 1979

Task 2E - EB/DOR, MEB & MTEB/DSS

- Evaluate CE/EPRI Model Boiler Studies - December 1978
- Review RES sponsored program at BNL - June 1979
- Evaluate other PWR vendors test programs for resolving tube denting problems - Summer 1979
- Fstablish water chemistry criteria - September 1979

Task 2F - EB/DOR, MTEB/DSS

- Review and evaluate Battelle Columbus program of eddy current inspection - October 1977.
- Review W activities in inspection techniques - November 1978 (targeted)
- Review EPRI Round Robin - November 1978

Task 2G - EB/DOR, MTEB/DSS

- Recommendations for revision of Regulatory Guide 1.83 - Winter 1979

Task 2H - EB, RSB & EEB/DOR

- Review and evaluate Surry plans for prototype steam generator replacement (starting Summer 1977).
- Review and evaluate Turkey Point plans for prototype steam generator replacement (starting Summer 1977).
- Establish generic NRC Steam Generator Replacement Position - January 1979

Task 2I - AB, MEB & MTEB/DSS

- Review and evaluate new design/ material concepts and new system component requirements for safe operation of steam generators in new PWR facilities.
- Develop analytical capabilities to determine the tolerable number of tube ruptures during transient events in new PWR facilities.
- Establish NRC Criteria for new PWR facilities.

8. Potential Problems

Except for steam generator replacement there is no apparent short term resolution of tube denting in affected Westinghouse plants. The many programs underway to resolve tube denting in presently operating plants may bring about a partial solution, by arresting denting through a cleaning program, sometime early in 1979.

However, by establishing quantitative plugging criteria for dented tubes, and requiring scheduled inspections, varying with the degree of denting observed, safety concerns can be minimized to the point where continued operation can be justified.

Finally, completion of many of the indicated tasks will depend on the scheduled completion of programs sponsored by organizations outside NRR. As with most experimental investigations, periodical delays can be expected, which may delay completion of some of the tasks indicated in the Task Action Plan.

WESTINGHOUSE STEAM GENERATOR TUBE INTEGRITY
TASK PHASE DIAGRAM
CONDENSER IN-LEAKAGE, TASK 2E . DSS, DOR (BNL) . WATER CHEMISTRY

WESTINGHOUSE STEAM GENERATOR TUBE INTEGRITY

TASK PHASE DIAGRAM