OMB No: 3150-0011
NRCB 89-01, Supplement 2

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

June 28, 1991

NRC BULLETIN NO. 89-01, SUPPLEMENT 2: FAILURE OF WESTINGHOUSE STEAM GENERATOR TUBE MECHANICAL PLUGS

Addressees:

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

Purpose:

This bulletin supplement requests that actions similar to those requested in NRC Bulletin 89-01, "Failure of Westinghouse Steam Generator Tube Mechanical Plugs," be extended to include all Westinghouse mechanical plugs fabricated from thermally treated Inconel 600. These actions are to ensure that these plugs will continue to provide adequate assurance of reactor coolant pressure boundary (RCPB) integrity under normal operating, transient, and postulated accident conditions.

Description of Circumstances:

Bulletin 89-01 requested that licensees determine whether certain mechanical plugs supplied by Westinghouse are installed in their steam generators and, if so, that an action plan (including plug repairs and/or replacement) be implemented to ensure that these plugs will continue to provide adequate assurance of RCPB integrity. This request applied only to plugs fabricated from Inconel 600 heats NX-3279, NX-3513, NX-3962, and NX-4523 (hereafter referred to as group 1 heats) on the basis of field experience and laboratory studies indicating that plugs from group 1 heats are highly susceptible to primary water stress corrosion cracking (PWSCC). Such cracking led to a gross plug failure at the North Anna Power Station, Unit 1, resulting in a 75-gallon-per-minute primary-to-secondary leak. The bulletin requested that the subject repairs and/or replacements be accomplished according to a schedule consistent with an algorithm developed by Westinghouse (Reference 1, Revision 1), using as a benchmark the most conservative corrosion rate data from the field (observed at Millstone, Unit 2, for a plug fabricated from heat NX-3513).

After the NRC issued Bulletin 89-01, Westinghouse issued Revision 3 of Reference 1 providing complete listings of plug lifetimes categorized by plant, date of installation, and heat number. Lifetimes were listed for all Westinghouse mechanical plugs fabricated from thermally treated Inconel 600,

including plugs fabricated from group 1 heats and plugs fabricated from all other heats of thermally treated Inconel 600, hereafter referred to as group 2 heats. Group 2 heats include heat numbers NX-1989, NX-2386, NX-2387, NX-5222, NX-6135, NX-6323 (HW), and NX-6323 (CR). The lifetimes listed for plugs fabricated from group 1 heats were consistent with the approach requested in the bulletin. The lifetimes listed for plugs fabricated from group 2 heats were estimated using the same approach as for group 1, except that the estimates were adjusted upward by heat-specific "microstructural factors" to reflect the comparative time-to-cracking performance of each group 2 heat with heat NX-3513 during Westinghouse corrosion tests.

During the summer and autumn of 1990, the staff received reports of instances of PWSCC at two plants affecting group 2 heats of thermally treated Inconel 600. These instances (at Sequoyah Nuclear Power Plant, Unit 1, and North Anna Power Station, Unit 2) were described in Supplement 1 to Bulletin 89-01. At the Sequoyah Nuclear Power Plant, Unit 1, five plugs fabricated from heat NX-5222 were removed from the field to examine their condition. One of these five plugs was found to exhibit a circumferential crack above the expander. This crack consisted of two small cracks with a total length of approximately 15 degrees around the plug circumference and a maximum depth of penetration of 0.009 inch. Another plug was found to exhibit axial cracks below the expander. These five plugs had accumulated only 21 percent of the calculated plug lifetime, as given in Revision 3 of Reference 1.

At North Anna, Unit 2, 15 plugs fabricated from heat NX-6323(HW) were inspected using a Westinghouse eddy current test technique. Nine of these plugs were located on the hot-leg side, five of which exhibited evidence of minor leakage. Eight of the nine hot-leg plugs exhibited indications of axial and/or circumferential cracking above the expander. One of the plugs, which was removed from the field and examined, was found to contain a crack that extended 360 degrees around the plug circumference. The crack varied in depth between 74 percent and 99 percent of the plug wall thickness. No indications were found in the six cold-leg plugs that were inspected. The accumulated service time on these plugs was less than 20 percent of the calculated lifetime, as given in Revision 3 of Reference 1.

As documented in Reference 2, Westinghouse revised its algorithm for estimating plug PWSCC lifetimes in light of the accumulated plug experience to date. The revised algorithm included revised heat-specific "microstructural factors" for plugs fabricated from group 2 heats based on a more conservative treatment of Westinghouse corrosion test data. The revised algorithm also included a revised "time to PWSCC failure" versus plug temperature relationship, based on operating experience trends.

Table 2 of Reference 2 provided lifetime estimates, based on the revised algorithm, for all Westinghouse mechanical plugs fabricated from both group 1 and group 2 heats. These lifetime estimates were based on the heat specific microstructural factors given in Table 1 of Reference 2 and with the exception of heat NX-5222, were benchmarked against the aforementioned field data from Millstone, Unit 2. The lifetime estimates in Reference 2 for plugs fabricated

from heat NX-5222 were benchmarked against the most conservative field data from Sequoyah, Unit 1 (for heat NX-5222).

The staff believes that the field data for heat NX-5222 from Sequoyah Unit 1 are insufficient to justify a less conservative approach than Westinghouse is employing for other heats of thermally treated Inconel 600 (Reference 3). At the request of the NRC staff, Westinghouse has issued new lifetime estimates for plugs fabricated from heat NX-5222 (Reference 4). These revised estimates reflect the heat-specific microstructural factors given in Table 1 of Reference 2 and are benchmarked against the aforementioned field data from Millstone, Unit 2, consistent with the approach taken by Westinghouse for plugs from all other heats of thermally treated Inconel 600. The most up-to-date listing of plug lifetime estimates for all heats of thermally treated Inconel 600 is given in Table 2 of Reference 4.

Discussion:

Based on the recent field experience at Sequoyah, Unit 1, and North Anna, Unit 2, and the results of corrosion tests performed by Westinghouse, the staff has concluded that a systematic remedial action program, similar to that requested in the original bulletin for plugs fabricated for group 1 heats, is needed for all Westinghouse mechanical plugs fabricated from thermally treated Inconel 600 to ensure the continued integrity of the RCPB over both the short-term and long-term. For this reason, the actions requested in this bulletin supplement apply to all Westinghouse mechanical plugs fabricated from thermally treated Inconel 600. The requested schedule for implementing the necessary remedial actions is consistent with the Westinghouse plug lifetime estimates in Reference 4.

It is possible that future refinements to the plug lifetime estimates will become appropriate as additional field experience is accumulated. In addition, technical industry organizations such as Westinghouse and the Electric Power Research Institute/Steam Generator Reliability Project are continuing to examine this issue. The NRC staff is also monitoring developments on the issue and will issue further supplements to this bulletin if found to be warranted. Although not required by this bulletin supplement, addressees are encouraged to monitor the condition of the plugs through sample removal and examination of plugs as was done at Sequoyah, Unit 1, or by eddy current testing as was done at North Anna, Unit 2, thereby adding to the operational experience database.

Actions Requested:

1. Addressees are requested to verify that information contained in Table 2 of Reference 4 for their plants is correct for plugs fabricated from group 2 heats. (Addressees have previously verified similar information for group 1 plugs in response to the original bulletin.) The specific information to be verified is the number of Westinghouse mechanical plugs installed in the hot-leg and cold-leg side of each steam generator, categorized by heat number and date of installation. The plug operating temperatures for each plant given in this Table should also be verified. If information from this

Table is incorrect, addressees should provide correct information. Addressees are requested to so state if their plants have not installed Westinghouse mechanical plugs from group 2 heats.

2. Addressees are requested to take the following actions, to be implemented initially during any refueling outage or extended outage (greater than four weeks) which ends 60 days or more following receipt of this bulletin and during all future refueling outages. For the period of time between receipt of the bulletin and 60 days, the actions requested in the original version of this bulletin continue to be applicable for plugs fabricated from group 1 heats.

   a) Addressees should implement appropriate remedial actions (i.e., repair and/or replacement) for all plugs whose estimated lifetime in item 2b, below does not extend to the next refueling outage.

   b) Remaining lifetime estimates (in effective full power days (EFPD)) are given in Table 2 of Reference 4 in the column entitled "Remain EFPD to MIN." These remaining lifetime estimates are relative to reference dates given in the column entitled "Reference CALC Dates." These remaining lifetime estimates may be used directly. These estimates should be adjusted to reflect any corrections noted in Actions Requested, item 1.

   c) For refueling outages or extended outages ending prior to November 30, 1991, remedial actions for plugs fabricated from NX-5222 may be deferred until the next scheduled refueling outage.

   d) Installation of Westinghouse mechanical plugs fabricated from Inconel 600 should be discontinued.

   e) If for any refueling outage, the addressee does not plan to satisfy items 2a to 2d above, an alternative plan for insuring plug integrity, with appropriate technical justification, should be submitted to the NRC at least 30 days before the end of the refueling outage.

   f) Prior to any plug repairs or replacement, addressees are reminded that their responsibilities under ALARA require analysis of the various plug repair or replacement methods. In choosing a plug repair or replacement method, the licensee should consider the accessibility of the plugs and the dose reduction benefit of using robotic manipulators. Prior to plug repair or replacement, the licensee should consider steam generator decontamination and/or local shielding to reduce working area dose rates.

Reporting Requirements:

Pursuant to Section 182a of the Atomic Energy Act and 10 CFR 50.54(f), addressees shall submit a letter within 30 days of receipt of this bulletin containing:

1. The information under Actions Requested, item 1.

2. A statement indicating whether or not the actions in Actions Requested, item 2 have been or will be taken. If alternative actions are proposed, supporting justification shall be provided.

The written reports required above shall be addressed to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555, under oath or affirmation. In addition, a copy shall be submitted to the appropriate regional administrator.

Backfit Discussion:

This supplement expresses new staff positions which are considered to be backfits justified under the criteria of 10 CFR 50.109(a)(4)(i) [compliance exception backfit]; in addition, the requirement for a response is considered to be justified under the criteria of 10 CFR 50.54(f) [information request].

Plant Technical Specifications require plugging or sleeving of steam generator tubes which are found to be defective during inservice inspection. Such plugs or sleeves are necessary to ensure the continued integrity of the RCPB under normal operating, transient, and postulated accident conditions. However, mechanical plugs supplied by Westinghouse are subject to PWSCC attack, which adversely affects the RCPB. The actions requested in this bulletin supplement are necessary to ensure that these plugs will continue to provide adequate assurance of RCPB integrity under the above mentioned conditions. Thus, these actions are to ensure that defective tubes continue to be effectively plugged as required by the Technical Specifications, to ensure compliance with General Design Criteria 14 and 31 of 10 CFR Part 50, Appendix A, and to ensure compliance with the quality assurance requirements of Criterion XVI of 10 CFR Part 50, Appendix B.

A documented evaluation of the type described in 10 CFR 50.109(a)(6) was prepared to state the objectives of and reasons for the modification, and the basis for invoking the compliance exception. Because the bulletin supplement also requires submittal of written reports under 10 CFR 50.54(f), the document also contains the reasons for the information request in view of the potential safety significance of the problem. This document, which is a revised review package submitted to the Committee to Review Generic Requirements (CRGR), will be made available in the Public Document Room in association with the minutes of the 203rd meeting of the CRGR.

This request is covered by Office of Management and Budget Clearance Number 3150-0011 which expires on June 30, 1991. The estimated average burden hours are 160 man-hours per licensee response, including assessing of the new

recommendations, searching data sources, gathering and analyzing the data, and preparing the required letters. These estimated average burden hours pertain only to these identified response-related matters and do not include the time for actual implementation of the requested actions. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Records and Reports Management Branch, Division of Information Support Services, Office of Information Resources Management, US. Nuclear Regulatory Commission, Washington, D.C. 20555; and to the Paperwork Reduction Project (3150-0011), Office of Management and Budget, Washington, D.C. 20503.

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

Charles E. Rossi

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contact: Emmett Murphy, NRR
(301) 492-0710

References:

1. Westinghouse reports WCAP-12244 (proprietary version) and WCAP-12245 (non-proprietary version), "Steam Generator Tube Plug Integrity Summary Report," Revision 1, April 1989; Revision 3, November 1989.

2. Addendum to Revision 3 of Westinghouse reports WCAP-12244 (proprietary version) and WCAP-12245 (non-proprietary version), "Steam Generator Tube Plug Integrity Summary Report," December 1990.

3. Memorandum, C. Y. Cheng to J. E. Richardson, "Summary of Meeting with Westinghouse on October 11, 1990, Concerning Steam Generator Tube Plug Issue," May 22, 1991. (Available in the Public Document Room).

4. Addendum 2 to Revision 3 of Westinghouse reports WCAP-12244 (proprietary version) and WCAP-12245 (non-proprietary version), "Steam Generator Tube Plug Integrity Summary Report," May 1991.

Attachment: List of Recently Issued NRC Bulletins

LIST OF RECENTLY ISSUED NRC BULLETINS

Bulletin No.	Subject	Date of Issuance	Issued to
89-01, Supp. 1	Failure of Westinghouse Steam Generator Tube Mechanical Plugs	11/14/90	All holders of OLs or CPs for pressurized-water reactors (PWRs).
90-02	Loss of Thermal Margin Caused by Channel Box Bow	3/20/90	All holders of OLs or CPs for BWRs.
90-01	Loss of Fill-Oil in Transmitters Manufactured by Rosemount	3/9/90	All holders of OLs or CPs for nuclear power reactors.
89-03	Potential Loss of Required Shutdown Margin During Refueling Operations	11/21/89	All holders of OLs or CPs for PWRs.
88-10, Supplement 1	Nonconforming Molded-Case Circuit Breakers	8/3/89	All holders of OLs or CPs for nuclear power reactors.
89-02	Stress Corrosion Cracking of High-Hardness Type 410 Stainless Steel Internal Preloaded Bolting in Anchor Darling Model S350W Swing Check Valves or Valves of Similar Design	7/19/89	All holders of OLs or CPs for nuclear power reactors.
89-01	Failure of Westinghouse Steam Generator Tube Mechanical Plugs	5/15/89	All holders of OLs or CPs for PWRs.
88-08, Supplement 3	Thermal Stresses in Piping Connected to Reactor Coolant Systems	4/11/89	All holders of OLs or CPs for light-water-cooled nuclear power reactors.
88-07, Supplement 1	Power Oscillations in Boiling Water Reactors	12/30/88	All holders of OLs or CPs for BWRs.
88-11	Pressurizer Surge Line Thermal Stratification	12/20/88	All holders of OLs or CPs for PWRs.

OL = Operating License
CP = Construction Permit