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April 14, 1998

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Gentlemen:

Donald C. Cook Nuclear Plant Units 1 and 2
RESPONSE TO NRC GENERIC LETTER (GL) 97-06
DEGRADATION OF STEAM GENERATOR INTERNALS

This letter and its attachment provide information requested in GL 97-06, concerning steam generator internals degradation.

Sincerely,

E E Fitzpatrick

E. E. Fitzpatrick
Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 14th DAY OF APRIL, 1998

Linda L. Boelcke
Notary Public

My Commission Expires 01-21-2001

LINDA L. BOELCKE
Notary Public, Berrien County, MI
My Commission Expires January 21, 2001

/vlb

Attachment

c: J. A. Abramson
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NRC Resident Inspector
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A001

ATTACHMENT TO AEP:NRC:1166AM

RESPONSE TO NRC GENERIC LETTER 97-06
DEGRADATION OF STEAM GENERATOR INTERNALS

INTRODUCTION

Generic letter (GL) 97-06 was issued to alert addressees to foreign and domestic findings of damage to steam generator (SG) internals, emphasize the importance of performing comprehensive examinations of SG internals, and request information that will enable the NRC staff to verify the internals of Cook Nuclear Plant's SGs conform to the current licensing basis.

BACKGROUND AND DESCRIPTION OF CIRCUMSTANCES

French authorities have reported various SG tube support plate (TSP) damage mechanisms. Damage has included wastage in the uppermost TSP due to misapplication of a chemical cleaning process, broken TSP ligaments resulting from inadequate clearance for differential thermal expansion, and TSP wastage at various elevations apparently involving a corrosion or erosion-corrosion mechanism of undetermined origin.

Other instances of internals degradation include wrapper drop/cracking at a foreign utility that is suspected to have been caused by severe cooling transients, and instances of erosion-corrosion of eggcrate supports in untubed areas initiated by unknown causes that occurred at a domestic facility.

These instances highlight the potential for degradation mechanisms that may lead to TSP and tube wrapper damage. As a result of this concern, GL 97-06 requests:

1. Discussion of any programs in place to detect degradation of SG internals and a description of inspection plans (scope, frequency, methods, and equipment). This discussion should address the following information for each facility.

   a. Whether inspection records have been reviewed for indications of TSP signal anomalies from eddy current testing of SG tubes that may be indicative of support plate or ligament damage.

   b. Whether visual or video camera inspections have been performed on the secondary side to gain information on the condition of SG internals (e.g., support plates, tube bundle wrappers, etc.).

   c. Whether degradation of SG internals has been detected, and how it was assessed and dispositioned.

2. In the event no program is in place to detect internals degradation, provide a discussion or justification for development of a program or why such a program is not needed.

Prior to issuance of this GL, Westinghouse Owners Group (WOG), Electric Power Research Institute (EPRI), and Nuclear Energy Institute (NEI) developed an action plan to assess the susceptibility of SG secondary side degradation. We intend to follow the industry action plan as modified by our site-specific experience. Included in the action plan is a requirement to understand the causal factors involved in the degradation experienced in the French units. This information is captured in EPRI report GC-109558, "Steam Generator Internals Degradation:

Modes of Degradation Detected in EdF Units". This report was submitted to the NRC via an NEI letter, dated December 19, 1997.

WOG has reviewed EPRI GC-109558 relative to the design of series 51 SGs and determined limited potential susceptibility. For plants with series 51 SGs, this conclusion is documented in WCAP-15002, revision 1, "Evaluation of EdF Steam Generator Internals Degradation - Impact of Causal Factors on Westinghouse 51 Series Steam Generators", December 1997. The series 51 SGs are the most similar model SG to that of the Electricité de France (EdF) units and are installed in unit 1.

WCAP-15002, revision 1, documents visual inspections performed at the series 51 SG plants. It was concluded that the number of plants that have been inspected and the inspection results demonstrate that the causal factors identified by EdF do not jeopardize the continued operability of Westinghouse series 51 SGs. This conclusion is supported by the capability of eddy current inspections to detect detrimental effects on tubing due to wear caused by TSP ligament degradation, loose parts, and secondary side flow distribution changes. Foreign object search and retrieval efforts are typically conducted as standard practice to discover or retrieve loose parts, thus limiting the potential for damage.

A response to GL 97-06 has been completed for unit 1 addressing the susceptibility of the unit 1 SGs to internals degradation, specific unit 1 inspection practices and recent inspection results, along with a discussion of subsequent plant operation with potential SG internals degradation of the type experienced in the French units (and other types of degradation experienced domestically). This discussion begins in the "UNIT 1 SG PROGRAM (INTERNALS INSPECTION)" section of this attachment.

Because a detailed Westinghouse evaluation has not been performed for our unit 2 SGs, inspection recommendations have been identified on an interim basis. Industry representatives have indicated that evaluations should be completed by May 1998, and the results will be factored into the unit 2 SG program. As such, the response to item 1 for unit 2, which is detailed in the "UNIT 2 SG PROGRAM (INTERNALS INSPECTION)" section of this attachment, may be modified in the future as dictated by the results of the pending evaluation.

UNIT 1 SG PROGRAM (INTERNALS INSPECTION)

SG Description

Unit 1 contains four Westinghouse series 51 SGs that were placed in service in 1975. Key design features include alloy 600 mill annealed tubing, a partial depth hardroll expansion at the tube-to-tubesheet joint, and drilled carbon steel support plates. The nominal tube outside diameter (OD) is 0.875 inches with a nominal wall thickness of 0.050 inches.

The four unit 1 SGs are presently scheduled for replacement in the year 2000.

Related Industry Findings

As discussed in WCAP-15002, revision 1, eighteen plants with series 51 SGs supplied information to the WOG concerning results of SG secondary side inspections and relevant tube inspections for TSP conditions. These results did not report detection of several modes of degradation experienced in the EdF units. There is no evidence of post-chemical cleaning inspections indicating any significant material loss, nor is there evidence of wrapper having dropped. While TSP ligament cracking has occurred in units with carbon steel support plates with drilled round holes and flow holes, there is no evidence indicating TSP ligament cracking or thinning that is progressive and continuing.

The following table summarizes the applicable WOG conclusions concerning the susceptibility of SGs like our unit 1 series 51 SGs to secondary side internals degradation.

TABLE 1

DEGRADATION TYPE	LEVEL OF SUSCEPTIBILITY
Erosion Corrosion:	
Moisture Separator	X
TSP Flow Hole/Ligaments	L
Feed Ring/J-Tubes	N
Cracking:	
TSP Ligaments Near Wedges **	N
TSP Ligaments Near Patch Plates	X *
Carbon Steel TSP Ligaments (random areas)	X *
Wrapper Near Supports **	N
Other:	
Wrapper Drop **	N

X = observed in some SGs
N = not susceptible to EdF casual factors
L = low susceptibility to EdF casual factors
* = various indication of degradation may be artifacts of manufacturing related to patch plate plug welds and/or drilling alignment
** = various Westinghouse design features are beneficial relative to some of the SG design features of foreign manufacturers

Site-Specific Findings

The unit 1 SGs were last inspected in the spring of 1997. In addition to the standard eddy current tube inspection, additional measures were performed to assure the integrity of the SG internals. These inspections, coupled with related findings from previous inspections, demonstrate that the areas noted in table 1 have been periodically examined with no abnormal conditions noted.

The following discussion presents the internals inspection scope and findings for the unit 1 1997 refueling outage (U1R97).

A 100% computer data screening (CDS) sort was performed on the low frequency bobbin coil data from each SG to address the potential for TSP damage or ligament cracking. Indications of possible ligament damage were examined using a motorized rotating pancake coil (MRPC) probe. The indications were subsequently dispositioned as having no degradation found (NDF) or determined to be aligned with the patch plate, thus yielding a "false" indication. One tube, R39/C22 in SG 11 was noted to have a 0.78 volt MRPC indication at the seventh hot leg support plate, near the wedge location. Research of the previous outage data confirmed this condition has been present for at least three years. This indication will continue to be monitored during future eddy current inspections.

Regarding the performance of secondary side visual inspections, the following activities were performed in each SG (unless otherwise noted) during the U1R97 foreign object search and retrieval operations:

- Pre-Sludge Lance Inspection - A visual inspection was performed to identify the tubing/sludge conditions at the tubesheet prior to lancing. This inspection included the annulus and divider lane.

- Post-Lance Inspection - A visual inspection was performed to verify the effectiveness of the sludge removal process and general tubesheet/tubing conditions at the top of the tubesheet. The inspection consisted of the annulus, divider lane and an inner bundle pass in both the hot and cold leg sides.

- Wrapper Barrel Inspection - This visual inspection was performed to verify the integrity of the wrapper barrel support structure.

- First Tube Support Ligament (2 SGs) - This inspection involved a visual review of the first TSP between the wrapper barrel and the tube bundle directly above the handhold.

The pre/post-lance inspections confirmed the effectiveness of the sludge removal operations and the general condition of the tubing at the tubesheet. No anomalies or loose parts were noted by the inspection. The wrapper barrel inspection produced no evidence of slippage or movement. Additional verification of the integrity of the support structure was provided by the successful installation of the sludge lance equipment. The lack of any interferences during this installation provided assurance that no deformation had occurred. Inspections of the first support plate identified no signs of anomalies in either of the two SGs inspected.

While no inspections were performed during U1R97 on the upper internals, previous inspections have identified only minimal wear. During the 1995 inspection, fifteen J-nozzles and the feedring tee section of one SG were inspected. The J-nozzles were termed to be in very good condition, with no thinning observed on the thermal liner and tee. Prior to the 1995 inspection, extensive inspections were conducted in 1989 in which visual inspections were conducted on the J-nozzles of three SGs. The visual examination of one of

these SGs was supplemented by an added ultrasonic test (UT) examination. Neither the visual or UT examinations noted any apparent degradation.

These inspections have indicated that degradation in the upper internals is a slow progressing phenomena. Based on minimal degradation to date and the near end of life for these SGs, no examinations were performed during U1R97.

Safety Assessment

The following safety concerns have been postulated by WOG relative to the French SG internals degradation experience.

- Loss of support in the tube bundle leading to wear, and possible primary-to-secondary leakage or inadequate burst margins.
- Increased TSP deformation during a postulated loss-of-coolant accident (LOCA) plus safe shutdown earthquake (SSE) event, resulting in unacceptable SG tube collapse or secondary-to-primary inleakage.
- Generation of a loose object in the secondary side of a SG that may result in tube wear or impacting, and possibly primary-to-secondary leakage.

As discussed below, industry experience and various standard practices are typically employed to provide assurance of SG integrity and negate the potential for these concerns. As evidenced from the previously discussed U1R97 inspection results, our unit 1 experiences and practices mirror that of the industry.

Based on a review of the table 1 information, the only degradation types that may occur domestically that could result in the loss of TSP integrity are TSP flow hole/ligament erosion-corrosion, TSP ligament cracking near the patch plates, and TSP ligament cracking in random areas. There is no industry evidence of post-chemical cleaning inspections indicating significant material loss, nor is there evidence of any wrapper having dropped. While TSP ligament cracking has occurred in units with carbon steel support plates with drilled round holes and flow holes, there is no evidence indicating TSP ligament cracking or thinning that is progressive and continuing. Utilities with series 51 SGs with carbon steel support plates inspect a significant percentage of SG tubes every outage with a bobbin coil probe (unit 1 inspects 100%). If sections of the tube support were missing, it would be readily detectable because of a lack of eddy current response at the TSP elevation.

There is no increased susceptibility to ligament cracking near the wedge supports in the series 51 SG design. Either there are no flow holes extending to the periphery at the wedge locations, or the wedges are not welded to the TSPs, as is the case with the EdF 51M SG. Existing calculations evaluating the effects of LOCA plus SSE loadings on the tube bundle continue to apply in determining whether certain tubes should be excluded from application of the voltage based plugging criteria, or whether certain tubes should be removed from service in plants that do not currently have the criteria, but may have SG tubes experiencing cracking at TSP intersections.

Another occurrence resulting from SG internal degradation that may affect a SG in performing its intended safety function is the potential for tube wear and primary-to secondary leakage due to the generation of a loose object on the secondary side of the SG. This may occur due to erosion-corrosion of the moisture separators, feed ring/J-nozzle, or TSP flow holes, or the occurrence of TSP ligament cracking. If primary-to-secondary leakage should occur because of tube wear from a loose object, the expected consequences would be bounded by a single tube rupture event and, therefore, would remain within the current licensing basis of the plant. It is our position that loose objects should be removed whenever possible. Tubes observed to have visible damage are eddy current inspected and plugged as necessary. Elements of the SG program, including eddy current inspection, foreign object search and retrieval during each refueling outage, and loose parts monitoring are in place to help ensure the maintenance of tube integrity during plant operation.

Because no internals degradation of consequence has been observed on the unit 1 SGs, it is expected that near term degradation would be limited in extent, such that the tubes will remain capable of sustaining the conditions of normal operations, including operational transient, design basis accidents, external events, and natural phenomena, permitting the affected SG to perform its safety function.

Inservice Inspection Plan

Because of the pending SG replacement, it is projected that the unit 1 SGs will undergo only one more inspection prior to the replacement outage. Based on the previous discussions, the upcoming inspection plan will closely mirror activities performed in 1997. The planned workscope is summarized as follows.

- A 100% CDS scan will be performed on the bobbin coil data for evidence of support plate/ligament damage. Indication disposition will be by MRPC probe. Note that the bobbin coil examination will be performed on 100% of the in-service tubing.

- Foreign object search and retrieval operations will be performed in each SG to access the tubing and support structure conditions as well as verify the sludge conditions within the SGs. Accessible tubesheet surfaces and tubes at the top of the tubesheet will be targeted during the inspection.

- During sludge lance operations to be performed in each SG, it will be verified that the lancing equipment can be inserted without interference. Successful installation will provide verification of wrapper integrity. If interference is detected, the lower wrapper support blocks will be visually inspected. The wrapper block inspection will also be conducted if any evidence of tube damage in the periphery of the first TSP is detected.

- Inspections will be performed on the first and uppermost TSP of one SG to assess fouling conditions and identify any evidence of corrosion or damage.

- Based on site inspection experience, no upper bundle inspections are planned during the upcoming inspection.

- Should the unit 1 SGs be replaced during the next outage, our inspection plan will be revised appropriately.

UNIT 2 SG PROGRAM (INTERNALS INSPECTION)

SG Description

In 1989, the four original unit 2 Westinghouse series 51 SGs were replaced with Westinghouse series 54F SGs. Key design features of the replacement SGs include thermally treated alloy 690 tubing, a full depth hydraulic expansion at the tube-to-tubesheet joint, quatrefoil stainless steel support plates, increased row 1 U-bend radius, and heat treated low row U-bends. The nominal tube OD is 0.875 inches, with a nominal wall thickness of 0.050 inches.

Related Industry Findings

As discussed in WCAP-15002, revision 1, twelve plants with series D, E, 44F, and F SGs supplied information to the WOG concerning results of SG secondary side inspections and relevant tube inspections for TSP conditions. For the most part, the findings did not report detection of several modes of degradation experienced in the EdF units. There is no evidence of post-chemical cleaning inspections indicating significant material loss, nor is there evidence of any wrapper having dropped. While TSP ligament cracking has occurred in units with carbon steel support plates with drilled round holes and flow holes, there is no evidence indicating TSP ligament cracking or thinning that is progressive and continuing.

The following table summarizes the applicable WOG conclusions concerning the susceptibility of SGs like the unit 2 series 54F SGs to secondary side internals degradation.

TABLE 2

DEGRADATION TYPE	LEVEL OF SUSCEPTIBILITY
Erosion Corrosion:	
Moisture Separator	X
TSP Flow Hole/Ligaments	NA
Feed Ring/J-Nozzles	X
Cracking:	
TSP Ligaments * **	L
Wrapper Near Supports **	L
Other:	
Wrapper Drop **	L

X = observed in some SGs
L = low susceptibility
NA = not applicable
* = various indication of degradation may be artifacts of manufacturing related to patch plate plug welds and/or drilling alignment
** = various Westinghouse design features are beneficial relative to some of the SG design features of foreign manufacturers

Site-Specific Findings

The unit 2 SGs were last inspected in the fall of 1997. In addition to the standard eddy current tube inspection, other measures were performed to assure the integrity of the SG internals. These inspections, coupled with related findings from previous inspections and design attributes of the unit 2 series 54F SGs, demonstrate that the areas of interest as noted in table 2 have been addressed with no abnormal conditions noted. The following discussion presents the internals inspection scope and findings for the unit 2 1997 refueling outage (U2R97).

The following activities were performed in each SG (unless otherwise noted) during the U2R97 foreign object search and retrieval operations.

- Pre-sludge Lance Inspection - A visual inspection was performed to identify the tubing/sludge conditions at the tubesheet prior to lancing. This inspection included the annulus and divider lane.

- Post-Lance Inspection - A visual inspection was performed to verify the effectiveness of the sludge removal process and the general tubesheet/tubing conditions on the top of the tubesheet. Areas reviewed consisted of the annulus, divider lane and an inner bundle pass on both the hot and cold leg sides.

- Sixth and Seventh TSP (One SG) - A visual inspection reviewed the sixth and seventh TSPs to access sludge conditions and fouling conditions in the upper region of the one SG.

The pre/post-lance inspection confirmed the effectiveness of the sludge removal operations and the general condition of the tubing at the tubesheet. No degradation or signs of abnormalities were noted during the inspection.

The upper support plate inspection noted no signs of damaged components or degradation.

Regarding TSP damage or ligament cracking, eddy current assessments were not performed because the quatrefoil broached hole support plate design makes this technique not applicable for detecting damage. No abnormalities were detected in this area during the foreign object search and retrieval operations that would suggest damage of this nature. In general, erosion-corrosion induced degradation is viewed as a low susceptibility event because the plates are constructed of stainless steel.

Specific inspection of the wrapper barrel area was not performed. However, wrapper conditions did not affect the installation of the

sludge lancing equipment that was performed in each SG. Therefore, it was concluded that the wrapper had not slipped or moved.

While no inspections were performed during U2R97 on the upper internals, previous inspections have been performed. During the 1994 inspection, ten J-nozzles and the feedring tee section of one SG were inspected. No erosion was noted during the inspection. The original feedrings/J-nozzles were replaced when the unit 2 SGs were replaced in 1989. The replacement feedrings are constructed of extra strong carbon steel and the J-nozzles are made from alloy 600, which is less susceptible to erosion damage than the typical carbon steel J-nozzles.

These inspections indicate that degradation in the upper internals is a slow progressing phenomena. Based on minimal degradation to date, no examinations were scheduled for U2R97.

Safety Assessment

As noted in the unit 1 safety assessment, the following safety concerns have been postulated by the WOG relative to the French SG internals degradation experience.

- Loss of support leading to wear and possible primary-to-secondary leakage or inadequate burst margins.
- More significant TSP deformation during a postulated LOCA plus SSE event, resulting in unacceptable SG tube collapse or secondary-to-primary inleakage.
- Generation of a loose object in the secondary side of a SG which may result in tube wear or impacting and possibly primary-to-secondary leakage.

As discussed below, design features, industry experience, and various standard practices are typically employed to provide assurance of SG integrity and negate the potential for these concerns. Previously discussed U2R97 inspection results indicate our unit 2 experiences and practices are similar to that of the industry.

Based on a review of the table 2 information, the only degradation types that may occur domestically that would likely result in the loss of TSP integrity are TSP flow hole/ligament erosion-corrosion, TSP ligament cracking near the patch plates, and TSP ligament cracking in random areas. There is no industry evidence of post-chemical cleaning inspections resulting in the discovery of any significant material loss, nor is there evidence of any wrapper having dropped. No TSP ligament indications have been found in steam generators with stainless steel TSPs. This population includes the unit 2 SGs.

No increased susceptibility to ligament cracking near the wedge supports has been identified in the series D, E, 44F, and F (unit 2) SGs designs. Existing calculations evaluating the effects of LOCA plus SSE loadings on the tube bundle continue to apply in determining whether certain tubes should be excluded from application of the voltage based plugging criteria, or whether certain tubes should be removed from service in plants that do not currently have a criteria but may have SG tubes experiencing cracking at TSP intersections.

Another occurrence resulting from SG internal degradation that may affect a SG in performing its intended safety function is the potential for tube wear and primary-to-secondary leakage due to the generation of a loose object on the secondary side of the SG. This may occur because of erosion-corrosion of the moisture separators or the occurrence of TSP ligament cracking. If primary-to-secondary leakage should occur due to tube wear from a loose object, the expected consequences would be bounded by a single tube rupture event and would remain within the current licensing basis of the plant. It is our position that loose objects should be removed whenever possible. Tubes observed to have visible damage are eddy current inspected and plugged as necessary. Elements of the SG program, including eddy current inspection, foreign object search and retrieval during each refueling outage, and loose parts monitoring are in place to help ensure the maintenance of tube integrity during plant operation.

Because no internals degradation of consequence has been observed on the unit 2 SGs, it is expected that future degradation would be limited in extent such that the tubes will remain capable of sustaining the conditions of normal operations, including operational transient, design basis accidents, external events, and natural phenomena, permitting the affected SG to perform its safety function.

Based on the above, implementation of the following inspection plan is planned on the unit 2 SGs to address the various types of SG secondary side internals degradation that may occur in Westinghouse-designed SGs. This plan may be amended, pending the results of a detailed industry evaluation that is expected to be completed by mid-1998.

Inservice Inspection Plan

Given the primary side eddy current inspection resulting in a C-1 classification and the absence of secondary side findings during the last inspection, no inspection activities are planned at the end of the current cycle (cycle 12). Inspection scope for the subsequent outage has not been finalized. However, at a minimum, planned secondary side inspections will be similar to those performed in 1997. The planned workscope is summarized as follows.

- Foreign object search and retrieval operations will be performed in each SG to access the tubing and support structure conditions as well as verify the sludge conditions within the SGs. Accessible tubesheet surfaces and tubes at the top of the tubesheet will be targeted during the inspection.

- During sludge lance operations to be performed in each SG, it will be verified that the lancing equipment can be inserted without interference. Successful installation will provide verification of wrapper integrity. If interference is detected, the lower wrapper support blocks will be visually inspected. The wrapper block inspection will also be conducted if evidence of tube damage in the periphery of the first TSP is detected.

- Inspections will be performed on the first and uppermost TSP of one SG to assess fouling conditions and identify evidence of corrosion or damage.

- To verify conditions in the upper bundle area remain consistent with past inspections, an inspection will be performed on the moisture separator units and a population of J-nozzles and the feedring tee area of one SG.

CONCLUSIONS

The aforementioned inspection programs are based on industry experience and our site-specific inspection findings. We believe these programs are of a nature to adequately address concerns of internals degradation as noted in GL 97-06.