October 10, 2006

Mr. Rick A. Muench
President and Chief Executive Officer
Wolf Creek Nuclear Operating Corporation
Post Office Box 411
Burlington, KS 66839

SUBJECT: WOLF CREEK GENERATING STATION - ISSUANCE OF AMENDMENT RE: STEAM GENERATOR TUBE INSPECTIONS WITHIN THE TUBESHEET (TAC NO. MD2467)

Dear Mr. Muench:

The U.S. Nuclear Regulatory Commission (the Commission) has issued the enclosed Amendment No. 169 to Facility Operating License No. NPF-42 for the Wolf Creek Generating Station. The amendment consists of changes to the Technical Specifications (TSs) in response to your application dated June 30, 2006 (ET 06-0026).

The amendment revises TS 5.5.9, "Steam Generator (SG) Program," by changing the "Refueling Outage 14" to "Refueling Outage 15" in two places. This change extends the provisions for SG tube repair criteria and inspections that were approved for Refueling Outage 14, and the subsequent operating cycle, in Amendment No. 162 issued April 28, 2005, to the upcoming Refueling Outage 15, and the subsequent operating cycle.

A copy of our related Safety Evaluation is enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

/RA/

Jack Donohew, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-482

Enclosures: 1. Amendment No. 169 to NPF-42
2. Safety Evaluation

cc w/encls: See next page

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ADAMS Accession Nos.: PKG ML062580016 (ML062580019, TS ML062780453)

OFFICE	NRR/LPL4/PM	NRR/LPL4/LA	CSGB/BC	OGC-NLO w/comments	NRR/LPL4/BC
NAME	JDonohew	LFeizollahi	AHiser	JRund	DTerao
DATE	9/20/06	10/3/06	9/13/06	9/29/06	10/4/06

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WOLF CREEK NUCLEAR OPERATING CORPORATION

WOLF CREEK GENERATING STATION

DOCKET NO. 50-482

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 169
License No. NPF-42

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment to the Wolf Creek Generating Station (the facility) Facility Operating License No. NPF-42 filed by the Wolf Creek Nuclear Operating Corporation (the Corporation), dated June 30, 2006, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, as amended, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and Paragraph 2.C.(2) of Facility Operating License No. NPF-42 is hereby amended to read as follows:

   2. Technical Specifications

      The Technical Specifications contained in Appendix A, as revised through Amendment No. 169, and the Environmental Protection Plan contained in Appendix B, both of which are attached hereto, are hereby incorporated in the license. The Corporation shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. The license amendment is effective as of its date of issuance and shall be implemented prior to entry into Mode 4 during the startup from Refueling Outage 15, scheduled to begin in October 2006.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

David Terao, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: October 10, 2006

ATTACHMENT TO LICENSE AMENDMENT NO. 169

FACILITY OPERATING LICENSE NO. NPF-42

DOCKET NO. 50-482

Replace the following page of the Appendix A Technical Specifications with the attached page. The revised page is identified by an amendment number and contains marginal lines indicating the areas of change. The corresponding overleaf page is provided to maintain document completeness.

REMOVE	INSERT
5.0-12	5.0-12

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 169

TO FACILITY OPERATING LICENSE NO. NPF-42

WOLF CREEK NUCLEAR OPERATING CORPORATION

WOLF CREEK GENERATING STATION

DOCKET NO. 50-482

1.0 INTRODUCTION

By letter dated June 30, 2006 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML061870347), Wolf Creek Nuclear Operating Corporation (the licensee) submitted an amendment request for Wolf Creek Generating Station (WCGS) regarding the steam generator (SG) tube inspection and plugging requirements in the Technical Specifications (TSs). The amendment would revise TS 5.5.9, "Steam Generator (SG) [Tube Surveillance] Program," by changing the "Refueling Outage 14" to "Refueling Outage 15" in two places to extend the provisions for SG tube repair criteria and inspections that were approved for Refueling Outage 14, and the subsequent operating cycle, in Amendment No. 162 issued April 28, 2005 (ADAMS Accession No. ML051160100), to the upcoming Refueling Outage 15, and the subsequent operating cycle.

The existing inspection and plugging requirements for portions of the SG tubing within the hot-leg tubesheet region that are applicable only to the portion of tubing within the upper 17 inches of the tubesheet thickness are not being changed. The allowance that the portion of tubing below 17 inches from the top-of-the-tubesheet (TTS) is excluded from these inspection and plugging requirements is also not being changed. The amendment would only extend the current inspection and plugging requirements to the upcoming Refueling Outage 15, which is scheduled to begin in October 2006, and the subsequent operating cycle.

2.0 BACKGROUND

The licensee has four Model F SGs designed and fabricated by Westinghouse at WCGS. There are 5,626 tubes in each SG, each with an outside diameter of 0.688 inches and a nominal wall thickness of 0.040 inches. The tubes are hydraulically expanded for the full depth of the tubesheet at each end and are welded to the tubesheet at the bottom of each expansion.

The licensee has been using bobbin probes for inspecting the length of tubing within the tubesheet. However, the bobbin probe is not capable of reliably detecting stress corrosion cracks (SCC) in the tubesheet region should such cracks be present. For this reason, the licensee has been supplementing the bobbin probe inspections with rotating coil probes in a

region extending from 3 inches above the TTS to 3 inches below the TTS. This zone includes the tube expansion transition zone located at the TTS. The expansion transition contains significant residual stress and was considered a likely location for SCC should it ever develop. Until the fall of 2004, there had not been any reported instances of SCC affecting the tubesheet region of thermally-treated alloy 600 tubing, either at WCGS or other nuclear power plants in the United States.

In the fall of 2004, crack-like indications were found in tubes in the tubesheet region of Catawba Nuclear Station, Unit 2 (Catawba), which has Westinghouse Model D5 SGs. Like WCGS, the Catawba SGs employ thermally-treated alloy 600 tubing that is hydraulically expanded against the tubesheet. Catawba had accumulated 14.7 effective full power years (EFPY) of service, slightly less than the EFPYs for the SGs at WCGS, with a comparable hot-leg operating temperature. The crack-like indications at Catawba were found in bulges (or over-expansions) in the tubesheet region, in the tack roll region, and in the tube-to-tubesheet weld. The tack expansion is an initial 0.7-inch-long expansion at each tube end and is formed prior to the hydraulic expansion over the full tubesheet depth. Its purpose was to facilitate performing the tube to tubesheet weld. Crack-like indications were found in a bulge in one tube and in the tack expansion in nine tubes. Approximately 6 of the 196 tube-to-tubesheet weld indications extended into the parent tube.

During Refueling Outage 14 (circa April 2005), as a result of the Catawba findings, the licensee expanded the scope of previous rotating coil inspections at WCGS to address the potential for cracks within the thickness of the tubesheet down to 17 inches below the TTS. However, the licensee believes that any flaws located at elevations more than 17 inches below the TTS (i.e., in the bottom 4 inches of the tubesheet region, including the tack expansion region and the tubing in the vicinity of the welds) have no potential to impair tube integrity and, thus, do not pose a safety concern. Following the licensee's license amendment request dated April 18, 2005, the Nuclear Regulatory Commission (NRC) staff reviewed and approved Amendment No. 162 for Wolf Creek, by letter dated April 28, 2005, modifying the inspection and plugging requirements for portions of the SG tubing within the hot-leg tubesheet region to make these requirements applicable only to the portion of tubing within the upper 17 inches of the tubesheet thickness. The portion of tubing below 17 inches from the TTS would be excluded from these inspection and plugging requirements.

At the time Amendment No. 162 was issued, it applied only to Refueling Outage 14 and the subsequent fuel cycle. In the current application dated June 30, 2006, the licensee is requesting that the same SG tube inspection and plugging requirements be extended to include the upcoming Refueling Outage 15 and the subsequent operating cycle.

By letter dated February 21, 2006 (ADAMS Accession No. ML060600456), the licensee requested a separate amendment for WCGS that would further limit the applicability of the TS inspection and plugging requirements to the upper 2.7 to 7 inches of the tubesheet thickness. This amendment would reduce the current SG tube inspection and plugging requirements. The NRC staff requested additional information concerning this amendment request by letter dated June 27, 2006 (ADAMS Accession No. ML061650099). As documented in the letter dated June 27, 2006, the licensee stated it would not be able to respond with the requested information before Refueling Outage 15, which is scheduled for October 2006. Thus, the NRC staff could not complete its review of the application dated February 21, 2006, in time to support the upcoming Refueling Outage 15 inspections and, therefore, the licensee has requested a

change TS 5.5.9 to have the current SG tube inspection and plugging requirements extended to Refueling Outage 15 and the subsequent fuel cycle.

3.0 REGULATORY EVALUATION

In Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.36, "Technical specifications," the NRC issued a rule and established its regulatory requirements related to the content of TSs. In doing so, the NRC emphasized those matters related to the prevention of accidents and mitigation of consequences of such accidents. As recorded in the Statements of Consideration, Technical Specifications for Facility Licenses: Safety Analysis Reports (33 FR 18610, December 17, 1968), the NRC noted that licensees are expected to incorporate into their plant TSs those items that are directly related to maintaining the integrity of the physical barriers designed to contain radioactivity. Pursuant to 10 CFR 50.36, TSs are required to include items in five specific categories related to station operation. Specifically, those categories include: (1) safety limits, limiting safety system settings (LSSSs), and limiting control settings; (2) limiting conditions for operation (LCOs); (3) surveillance requirements (SRs); (4) design features; and (5) administrative controls. However, the rule does not specify the particular requirements to be included in a plant's TSs. The requirements on SG tube inspections and plugging requirements are in TS 3.4.17, “Steam Generator (SG) Tube Integrity,” and TS 5.5.9. However, although TS 3.4.17 was approved by letter dated May 8, 2006, to be added to the TSs in Amendment No. 164, it has not yet been added to the TSs as of this date because Amendment No. 164 was approved to be implemented as late as prior to the entry into Mode 5 in the restart from the upcoming Refueling Outage 15.

The SG tubes function as an integral part of the reactor coolant pressure boundary (RCPB) and, in addition, serve to isolate radiological fission products in the primary reactor coolant from the secondary coolant and the environment. For the purposes of this safety evaluation (SE), SG tube integrity means that the tubes are capable of performing these safety functions in accordance with the plant design and licensing basis.

Title 10 of the *Code of Federal Regulations* (10 CFR) establishes the fundamental regulatory requirements with respect to the integrity of the SG tubing. Specifically, the General Design Criteria (GDC) in Appendix A to 10 CFR Part 50 state that the RCPB shall have “an extremely low probability of abnormal leakage . . . and gross rupture" (GDC 14), "shall be designed with sufficient margin" (GDCs 15 and 31), shall be of "the highest quality standards practical" (GDC 30), and shall be designed to permit "periodic inspection and testing . . . to assess . . . structural and leaktight integrity" (GDC 32). To this end, 10 CFR 50.55a specifies that components which are part of the RCPB must meet the requirements for Class 1 components in Section III of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code). Section 50.55a further requires, in part, that throughout the service life of a pressurized-water reactor (PWR) facility like WCGS, ASME Code Class 1 components meet the requirements, except design and access provisions and pre-service examination requirements, in Section XI, "Rules for Inservice Inspection [ISI] of Nuclear Power Plant Components," of the ASME Code, to the extent practical. This requirement includes the inspection and repair criteria of Section XI of the ASME Code. Section XI requirements pertaining to ISI of SG tubing are augmented by additional SG tube SRs in the TS.

As part of the plant licensing basis, applicants for PWR licenses are required to analyze the consequences of postulated design-basis accidents (DBAs) such as an SG tube rupture and

main steamline break (MSLB). These analyses consider the primary-to-secondary leakage through the tubing which may occur during these events and must show that the offsite radiological consequences do not exceed the applicable limits of the 10 CFR Part 100 guidelines for offsite doses, GDC 19 criteria for control room operator doses, or some fraction thereof as appropriate to the accident, or the NRC-approved licensing basis (e.g., a small fraction of these limits). No accident analysis for WCGS is being changed because of the proposed amendment and, thus, no radiological consequences of any accident analysis is being changed.

TS 5.5.9 requires that an SG tube program be established and implemented to ensure that SG tube integrity is maintained. SG tube integrity is maintained by meeting specified performance criteria (in TS 5.5.9.b) for structural and leakage integrity, consistent with the plant design and licensing bases. TS 5.5.9 requires a condition monitoring assessment be performed during each outage during which the SG tubes are inspected to confirm that the performance criterion is being met. TS 5.5.9 also includes provisions regarding the scope, frequency, and methods of SG tube inspections. Of relevance to the subject amendment request, these provisions require that the number and portions of tubes inspected and methods of inspection shall be performed with the objective of detecting flaws of any type that may be present along the length of a tube, from the tube-to-tubesheet weld at the tube inlet to the tube-to-tubesheet weld at the tube outlet, and that may satisfy the applicable tube repair criteria. The applicable tube repair criteria, specified in TS 5.5.9.c, are that tubes found by an inservice inspection to contain with a depth equal to or exceeding 40 percent of the nominal tube wall thickness shall be plugged.

The proposed amendment is applicable only during the upcoming Refueling Outage 15 and the subsequent operating cycle. The amendment (1) would limit the required inspections and any resulting plugging on the hot-leg side of the 21-inch-thick tubesheet region to the upper 17 inches of the tubesheet region and (2) is similar to the amendment approved for Refueling Outage 14 and the subsequent operating cycle (with minor differences discussed at the end of Section 4.2 below of this SE), and to other amendments approved for Unit 2 of both the Byron and Braidwood Nuclear Power Stations, and the Alvin W. Vogtle Electric Generating Plant.

4.0 TECHNICAL EVALUATION

4.1 Proposed Changes to the TSs

- TS 5.5.9.c.1, which provides for an alternate to the SG tube repair criteria of 40 percent of the nominal tube wall, currently states: "For Refueling Outage 14 and the subsequent operating cycle, degradation found in the portion of the tube below 17 inches from the top of the hot leg tubesheet does not require plugging. All tubes with degradation identified in the portion of the tube within the region from the top of the hot leg tubesheet to 17 inches below the top of the tubesheet shall be removed from service."

  The above statement would be revised to indicate Refueling Outage 15 instead of Refueling Outage 14.

- TS 5.5.9.d, which provides for SG tube inspections, currently states in part: "For Refueling Outage 14 and the subsequent operating cycle, the portion of the tube below 17 inches from the top of the hot leg tubesheet is excluded."

  The above statement would be revised to indicate Refueling Outage 15 instead of Refueling Outage 14.

4.2 Technical Evaluation

The tube-to-tubesheet joint consists of the tube, which is hydraulically expanded against the bore of the tubesheet, the tube-to-tubesheet weld located at the tube end, and the tubesheet. The joint was designed as a welded joint in accordance with Section III of the ASME Code, and not as a friction or expansion joint. The weld itself was designed as a pressure boundary element in accordance with the ASME Code, Section III. It was designed to transmit the entire end cap pressure load during normal and DBA conditions from the tube to the tubesheet with no credit taken for the friction developed between the hydraulically-expanded tube and the tubesheet. In addition, the weld serves to make the joint leak tight.

By its application, the licensee, in effect, is proposing to exempt, during Refueling Outage 15 and the subsequent operating cycle, the lower 4 inches of the 21-inch-deep tubesheet region from a tube inspection and to exempt tubes with flaw indications in the lower 4-inch zone from the need to plug. These exemptions currently apply only to Refueling Outage 14 and the subsequent operating cycle (which ends at the beginning of Refueling Outage 15). The latter part of this proposal (i.e., to exempt tubes from plugging) is needed as a practical matter since although rotating coil probe inspections will not be performed in this region, the bobbin probe will necessarily be recording any signals produced in this zone. This proposal, in effect, redefines the pressure boundary at the tube-to-tubesheet joint as consisting of a friction or expansion joint with the tube hydraulically expanded against the tubesheet over the top 17 inches of the tubesheet region. Under this proposal, no credit is taken by the licensee for the lower 4 inches of the tube or the tube-to-tubesheet weld in contributing to the structural or leakage integrity of the joint. The lower 4 inches of the tube and weld are, therefore, assumed not to exist.

The regulatory standard by which the NRC staff has evaluated the proposed amendment is that the amended TSs should continue to ensure that tube integrity will be maintained in the SGs at WCGS. Ensuring SG tube integrity includes the following: (1) maintaining structural safety margins consistent with the structural performance criteria in TS 5.5.9.b.1 and the design basis as is discussed in Section 4.2.1 (joint structural integrity) of this SE below; and (2) limiting the accident-induced primary-to-secondary leakage to values not exceeding the accident leakage performance criteria in TS 5.5.9.b.2 consistent with the licensing basis accident analyses. Maintaining tube integrity in this manner ensures that the amended TSs are in compliance with all applicable regulations. The NRC staff's evaluations of joint structural integrity and leakage integrity are discussed in Sections 4.2.1 and 4.2.2 of this SE, respectively.

The licensee is also proposing to plug, during Refueling Outage 15 and the subsequent operating cycle, all tubes found with degradation in the upper 17-inch region of the tubesheet on the hot leg side. This requirement is currently applicable only to Refueling Outage 14 and the subsequent operating cycle. The NRC staff finds that this proposed requirement is acceptable since it is more conservative than the current 40-percent plugging limit and will provide added

assurance that the length of tubing along the entire proposed 17-inch inspection zone will be effective in resisting tube pullout under tube end cap pressure loads and in resisting primary-to-secondary leakage between the tube and tubesheet.

The proposed amendment does not include the special inspection requirements applicable to the upper 17 inches of the tubesheet region which were included as part of Amendment No. 162, which was issued by the NRC staff on April 28, 2005 (ADAMS Accession No. ML0511601000), nor does it include the definitions of the words “bulge” and “overexpansion,” which accompanied the special inspection requirements. The requirements were deleted under Amendment No. 164, which was issued by the NRC staff on May 8, 2006, and new TS requirements governing SG tube integrity in accordance with Technical Specification Task Force 449, Revision 4 (TSTF-449) were defined. The NRC staff concluded that the new TSs, which are in accordance with TSTF-449, provide reasonable assurance that adequate tube inspections will be performed throughout the SGs, including inspections in the upper 17 inches of tubesheet region.

Amendment No. 164, which adopted TSs in accordance with TSTF-449, was issued with the following implementation date: "The license amendment is effective as of its date of issuance and shall be implemented prior to entry into Mode 5 in the restart from Refueling Outage 15, which is scheduled to begin in October 2006." Therefore, although the TSs in Amendment No. 164 are not required to be in the WCGS until during Refueling Outage 15 (i.e., before entry in Mode 5 in the plant restart from the outage), the licensee must meet the requirements in these TSs before it restarts WCGS from that refueling outage. This is acceptable to the NRC staff.

4.2.1 Joint Structural Integrity

Westinghouse has conducted analysis and testing to establish the engagement (embedment) length of hydraulically-expanded tubing inside the tubesheet that is necessary to resist pullout under normal operating and DBA conditions. Pullout is the structural failure mode of interest since the tubes are radially constrained against axial fishmouth rupture by the presence of the tubesheet. The axial force which could produce pullout derives from the pressure end cap loads due to the primary-to-secondary pressure differentials associated with normal operating and DBA conditions. The licensee’s contractor, Westinghouse, determined the required engagement distance on the basis of maintaining a factor of 3 against pullout under normal operating conditions and a factor of 1.4 against pullout under accident conditions. The NRC staff concurs that these are the appropriate safety factors to apply to demonstrate structural integrity. These safety factors are consistent with the safety factors embodied in the structural integrity performance criteria in TS 5.5.9.b.1 and with the plant design basis; namely, the stress limit criteria in ASME Code, Section III.

The resistance to pullout is the axial friction force developed between the expanded tube and the tubesheet over the engagement distance. The friction force is a function of the radial contact pressure between the expanded tube and the tubesheet. The radial contact pressure derives from several contributors including the following: (1) the contact pressure associated directly with the hydraulic expansion process itself, (2) additional contact pressure due to differential radial thermal expansion between the tube and tubesheet under hot operating conditions, (3) additional contact pressure caused by the primary pressure inside the tube, and (4) additional or reduced contact pressure associated with tubesheet bore dilation (distortion)

caused by tubesheet bow (deflection) as a result of the primary-to-secondary pressure load acting on the tubesheet. Westinghouse employed a combination of pullout tests and analyses, including finite element analyses, to evaluate these contributors. Based on these analyses and tests, Westinghouse concludes that the required engagement distances, which are to ensure the safety factor criteria against pullout are achieved, vary from about 2.2 to 7.0 inches depending on the radial location of the tube within the tube bundle, with the largest engagement distances needed toward the center of the bundle.

In its letter dated February 21, 2006, the licensee submitted a Westinghouse analysis with respect to whether 2.2 to 7.0 inches of engagement (termed H* criterion by Westinghouse) is adequate to ensure that the necessary safety margins against pullout are maintained. The NRC staff has not reviewed this analysis in sufficient detail to reach a conclusion on the acceptability of the analysis. Because of this, the licensee is proposing to keep the SG tube inspection and plugging requirements for Refueling Outage 14 and inspect the tubes in the tubesheet region such as to ensure a minimum of 17 inches of effective engagement, well in excess of the 2.2 to 7.0 inches that the Westinghouse analyses indicate are needed.

Based on the following considerations, the NRC staff concludes that the proposed 17-inch engagement length is acceptable to ensure the structural integrity of the tubesheet joint:

- The NRC staff estimates, based on the Westinghouse pullout tests, that the radial contact pressure produced by the hydraulic expansion and differential radial thermal expansion is such as to require an engagement distance of 8.6 inches to ensure the appropriate safety margins against pullout based on a no-slip criterion. This estimate is a mean minus one standard deviation estimate based on six pull tests. This estimate ignores the effect on needed engagement distance from internal primary pressure in the tube and tubesheet bore dilations associated with tubesheet bow. The NRC staff notes that from a tube pullout standpoint, the use of a “no slip” criterion is conservative. Allowing slippage of about 0.2 to 0.3 inches decreases the necessary engagement distance to 5.1 inches, again ignoring the effect on needed engagement distance from internal primary pressure in the tube and tubesheet bore dilations associated with tubesheet bow.

- The internal primary pressure inside the tube under normal operating and accident conditions also acts to tighten the joint relative to non-pressurized conditions, thus reducing the necessary engagement distance.

- Tubesheet bore dilations caused by tubesheet bow under primary-to-secondary pressure can increase or decrease contact pressure depending on the tube location within the bundle and on location along the length of the tube in the tubesheet region. Basically, the tubesheet acts as a flat, circular plate under an upward-acting net pressure load. The tubesheet is supported axially around its periphery with a partial restraint against tubesheet rotation provided by the SG shell and channel head. The SG divider plate provides a spring support against upward displacement along a diametral mid-line. Over most of the tubesheet away from the periphery, the bending moment resulting from the applied primary-to-secondary pressure load can be expected to put the tubesheet into tension at the top and compression at the bottom. Thus, the resulting distortion of the tubesheet bore (tubesheet bore dilation) tends to be such as to loosen the tube-to-tubesheet joint at the TTS and to tighten the joint at the bottom of the

tubesheet. The amount of dilation and resulting change in joint contact pressure would be expected to vary in a linear fashion from top to bottom of the tubesheet. Given the neutral axis to be at approximately the axial mid-point of the tubesheet thickness (i.e., 10.5 inches below the TTS), tubesheet bore dilation effects would be expected to further tighten the joint from 10 inches below the TTS to 17 inches below the TTS which would be the lower limit of the proposed tubesheet region inspection zone. Combined with the effects of the joint tightening associated with the primary pressure inside the tube, contact pressure over at least a 6.5-inch distance should be considerably higher than the contact pressure simulated in the above mentioned pull out tests. A similar logic applied to the periphery of the tubesheet leads the NRC staff to conclude that at the top 10.5 inches of the tubesheet region, contact pressure should be considerably higher than the contact pressure simulated in the above-mentioned pullout tests. Thus, the NRC staff concludes that the proposed 17-inch engagement distance (or inspection zone) is acceptable to ensure the structural integrity of the tubesheet joint.

4.2.2 Joint Leakage Integrity

If no credit is to be taken for the presence of the tube-to-tubesheet weld, a potential leak path between the primary to secondary is introduced between the hydraulically-expanded tubing and the tubesheet. In addition, not inspecting the tube in the lower 4 inches of the tubesheet region may lead to an increased potential for 100 percent throughwall flaws in this zone and the potential for leakage of primary coolant through the crack and up between the hydraulically-expanded tubes and tubesheet to the secondary system. Operational leakage integrity is assured by monitoring primary-to-secondary leakage relative to the applicable TS LCO limits. However, it must also be demonstrated that the proposed TS changes do not create the potential for leakage during DBAs to exceed the accident leakage performance criteria in TS 5.5.9.b.2, including the leakage values assumed in the plant licensing basis accident analyses. The licensee states that this is ensured by limiting primary-to-secondary leakage to 1 gallon per minute (gpm) in the faulted SG during an MSLB accident.

As discussed above, to support the H* criterion in the licensee's letter dated February 21, 2006, Westinghouse has developed a detailed leakage prediction model which considers the resistance to leakage from cracks located within the thickness of the tubesheet; however, the NRC staff has neither sufficiently reviewed, nor accepted, this model.

For the proposed 17-inch inspection zone, Westinghouse cited a number of qualitative arguments supporting a conclusion that a minimum 17-inch engagement length ensures that leakage during MSLB will not exceed two times the observed leakage during normal operation. Westinghouse refers to this as the “bellwether approach.” Thus, for an SG leaking at the TS LCO limit of 150 gallons per day (gpd), or 0.104 gpm, under normal operating conditions, Westinghouse estimates that leakage would not be expected to exceed 0.208 gpm, which is less than the 1 gpm assumed in the WCGS licensing basis accident analyses for the MSLB accident.

The factor-of-2 upper bound is based on the Darcy equation for flow through a porous media where leakage rate would be proportional to differential pressure. Westinghouse considered normal operating pressure differentials between 1,200 and 1,400 pounds per square inch (psi) and accident differential pressures on the order of 2,560 to 2,650 psi, essentially a factor of 2 difference. The factor of 2 as an upper bound is based on a premise that the flow resistance

between the tube and tubesheet remains unchanged. Westinghouse states that the flow resistance varies as a log normal linear function of joint contact pressure. The NRC staff concurs that the factor of 2 upper bound is reasonable, given the stated premise. The NRC staff notes that the assumed linear relationship between leak rate and differential pressure is conservative relative to alternative models such as Bernoulli or orifice models which assume leak rate to be proportional to the square root of differential pressure.

The NRC staff reviewed the qualitative arguments developed by Westinghouse regarding the conservatism of the aforementioned premise; namely, the conservatism of assuming that flow resistance between the expanded tubing and the tubesheet does not decrease under the most limiting accident relative to normal operating conditions. Most of the Westinghouse observations are based on insights derived from the finite element analyses performed to assess joint contact pressures and from test data relating leak flow resistance to joint contact pressure, neither of which has been reviewed by the NRC staff in detail. Among the Westinghouse observations is that for all tubes, there is at least an 11-inch zone in the upper 17 inches of the tubesheet where there is an increase in joint contact pressure and, thus, leak flow resistance, due to higher primary pressure inside the tube and changes in tubesheet bore dilation along the length of the tubes.

In Section 4.2.1 of this SE above, the NRC staff observed that there is at least a 6.5-inch zone over which changes in tubesheet bore dilations when going from unpressurized to pressured conditions should result in an increase in joint contact pressure. The contact pressure due to changes in tubesheet bore dilation should increase further over this 6.5-inch zone under the increased pressure loading on the tubesheet during accident conditions. Considering the higher pressure loading in the tube when going from normal operating to accident conditions, the NRC staff estimates on a qualitative basis that the length over which contact pressure would be expected to increase should be at least 10 inches, which is reasonably consistent with the more detailed Westinghouse analysis.

Although joint contact pressures and leak flow resistance decrease over other portions of the tube length, Westinghouse expects a net increase in total leak flow resistance on the basis of its insights from leakage test data that leak flow resistance is more sensitive to changes in joint contact pressure as contact pressure increases due to the linear log normal nature of the relationship. The NRC staff's depth of review did not permit it to credit this aspect of the Westinghouse analysis. However, it is clear from the above discussion that there should be no significant reduction in leakage flow resistance when going from normal operating to accident conditions.

Finally, the NRC staff has considered that undetected cracks in the lower 4 inches are unlikely to produce leakage rates during normal operation that would approach the TS LCO operational leakage limits during normal operation, thus providing additional confidence that such cracks will not result in leakage in excess of the values assumed in the accident analyses. Any axial cracks will be tightly clamped by the tubesheet against opening of the crack faces. In addition, little of the end cap pressure load should remain in the tube below 17 inches and, thus, any circumferential cracks would be expected to remain tight. Thus, irrespective of the flow resistance in the upper 17 inches of the tubesheet between the tube and tubesheet, the tightness of the cracks themselves should limit leakage to very small values.

Based on the above, the NRC staff concludes that there is reasonable assurance that the proposed exclusion for Refueling Outage 15, and the subsequent operating cycle, of the lower 4 inches of the tubes in the tubesheet region from the tube inspection and plugging and repair requirements will not impair the leakage integrity of the tube-to-tubesheet joint.

4.3 Conclusion

Based on the above evaluation, the NRC staff finds that the proposed amendment, which is applicable only to Refueling Outage 15 and the subsequent operating cycle, ensures that the structural and leakage integrity of the SG tube-to-tubesheet joint will be maintained during this period with structural safety margins consistent with the plant design basis, with leakage integrity within assumptions employed in the licensing basis accident analyses, and, thus, in accordance with the applicable regulations without undue risk to public health and safety. Because of this, the NRC staff further concludes that the proposed replacement of "Refueling Outage 14" by "Refueling Outage 15" in TS 5.5.9 meets GDCs 14, 15, 30, 31, and 32, and 10 CFR 50.36 and, therefore, the proposed amendment is acceptable.

The licensee has stated that it will implement this amendment prior to entry into Mode 4 during the restart of WCGS from the upcoming Refueling Outage 15. Because Mode 4 is when the SGs must first be operable in the restart from an outage, the NRC staff concludes that this implementation date is acceptable.

The TS page 5.0-12 that is being changed by this amendment, and the overleaf TS page 5.0-11 not being changed, are from Amendment No. 164 issued by NRC on May 8, 2006 (ADAMS Accession No. ML061280189), which completely changed and retitled TS 5.5.9. Although Amendment No. 164 was approved on May 8, 2006, it will not be implemented by the licensee until prior to entry into Mode 5 in the restart from the upcoming Refueling Outage 15. Because this amendment is to be implemented prior to entry into Mode 4 in the restart from the same refueling outage, it will be implemented after Amendment No. 164 and the appropriate TS pages to be changed are from that amendment.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Kansas State official was notified of the proposed issuance of the amendment. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration and there has been no public comment on such finding (71 FR 41845, published July 24, 2006). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

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