September 19, 2005

Mr. Christopher M. Crane, President
and Chief Nuclear Officer
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BYRON STATION, UNIT 2 - ISSUANCE OF AMENDMENT (TAC NO. MC7219)

Dear Mr. Crane:

The U.S. Nuclear Regulatory Commission (Commission) has issued the enclosed Amendment No. 144 to Facility Operating License No. NPF-66 for the Byron Station, Unit No. 2. The amendment is in response to your application dated May 24, 2005.

The amendment modifies the inspection requirements for portions of the steam generator (SG) tubes within the hot leg tubesheet region of the SGs.

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

Sincerely,

/RA/

Jon B. Hopkins, Senior Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. STN 50-455

Enclosures: 1. Amendment No. 144 to NPF-66
2. Safety Evaluation

cc w/encls: See next page

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<u>EXELON GENERATION COMPANY, LLC</u>

<u>DOCKET NO. STN 50-455</u>

<u>BYRON STATION, UNIT NO. 2</u>

<u>AMENDMENT TO FACILITY OPERATING LICENSE</u>

Amendment No. 144
License No. NPF-66

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

   A. The application for amendment by Exelon Generation Company, LLC (the licensee) dated May 24, 2005, 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, 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 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-66 is hereby amended to read as follows:

(2) Technical Specifications

The Technical Specifications contained in Appendix A (NUREG-1113), as revised through Amendment No. 144 and the Environmental Protection Plan contained in Appendix B, both of which were attached to License No. NPF-37, dated February 14, 1985, are hereby incorporated into this license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of the date of its issuance and shall be implemented within 30 days of the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Gene Y. Suh, Chief, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: 9/19/05

ATTACHMENT TO LICENSE AMENDMENT NO. 144

FACILITY OPERATING LICENSE NO. NPF-66

DOCKET NO. STN 50-455

Replace the following pages of the Appendix “A” Technical Specifications with the attached pages. The revised pages are identified by amendment number and contain marginal lines indicating the area of change.

Remove Pages	Insert Pages
5.5-9	5.5-9
5.5-12	5.5-12
5.5-13	5.5-13
5.5-14	5.5-14

<u>SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION</u>

<u>RELATED TO AMENDMENT NO. 144 TO FACILITY OPERATING LICENSE NO. NPF-66</u>

<u>EXELON GENERATION COMPANY, LLC</u>

<u>BYRON STATION, UNIT NO. 2</u>

<u>DOCKET NO. STN 50-455</u>

1.0 INTRODUCTION

By letter dated May 24, 2005 (ML051860117), Exelon Generation Company, (the licensee), requested changes to the Technical Specifications (TSs) for Byron Station, Unit 2.
The amendment requests involves a one-time change to TS 5.5.9, “Steam Generator (SG) Tube Surveillance Program,” regarding the required SG inspection scope for Byron Station, Unit 2, during Refueling Outage (RFO) 12 and the subsequent operating cycle. The proposed changes modify the inspection requirements for portions of the SG tubes within the hot leg tubesheet region of the SGs. Byron Station, Unit 1 is affected only due to the fact that Unit 1 and Unit 2 use common TSs. Specifically, the proposed changes would modify:

1.1 TS 5.5.9.b, SG Tube Sample Selection and Inspection

A new requirement has been added to state:

> For Unit 2 during Refueling Outage 12, a 20% minimum sample of all inservice tubes from the top of the hot leg tubesheet to 17 inches below the top of the tubesheet shall be inspected by rotating probe. This sample shall include a 20% minimum sample of the total population of bulges and overexpansions within the SG from the top of the hot leg tubesheet to 17 inches below the top of the tubesheet.

1.2 TS 5.5.9.e.6, Plugging or Repair Limit

Two new paragraphs have been added to state:

> For Unit 2 during Refueling Outage 12 and the subsequent operating cycle, this definition does not apply to degradation identified in the portion of the tube below 17 inches from the top of the hot leg tubesheet. Degradation found in the portion of the tube below 17 inches from the top of the hot leg tubesheet does not require plugging or repair.
>
> For Unit 2 during Refueling Outage 12 and the subsequent operating cycle, degradation identified in the portion of the tube from the top of the hot leg

tubesheet to 17 inches below the top of the tubesheet shall be plugged or repaired upon detection.

1.3 TS 5.5.9.e.8, Tube Inspection

A new paragraph has been added to state:

For Unit 2 during Refueling Outage 12 and the subsequent operating cycle, the portion of the tube below 17 inches from the top of the hot leg tubesheet is excluded.

1.4 TS 5.5.9.e, Acceptance Criteria

TS 5.5.9.e.12 has been added to define "bulge" and "overexpansion."

For Unit 2 during Refueling Outage 12 and the subsequent operating cycle:

Bulge refers to a tube diameter deviation within the tubesheet of 18 volts or greater as measured by bobbin coil probe; and

Overexpansion refers to a tube diameter deviation within the tubesheet of 1.5 mils or greater as measured by bobbin coil probe.

2.0 BACKGROUND

Byron Station, Unit 2, has four Model D5 recirculating, pre-heater type steam generators designed and fabricated by Westinghouse. The thermally treated Alloy 600 steam generator U-tubes have an outside diameter of 0.75-inch and a nominal wall thickness of 0.043-inch. The tube support plates are 1.125 inch thick stainless steel and have quatrefoil broached holes. The tubes are hydraulically expanded for the full depth of the tubesheet.

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 top of the tubesheet (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 Byron Station, Unit 2, or elsewhere in the U.S.

In the Fall of 2004, crack-like indications were found in tubes in the tubesheet region of Catawba Unit 2, which is of similar design to Byron Station, Unit 2 (i.e., Model D5 SGs with thermally treated Alloy 600 tubing) and which has accumulated a comparable operating time, 14.7 EFPY, at a comparable operating temperature. These crack-like indications 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 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.

As a result of the Catawba findings, the licensee plans to expand the scope of previous rotating coil inspections 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 below 17-inches below the TTS (i.e., in the bottom four 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. To avoid the unnecessary plugging or repair of tubes as would be required by the TS should inspection reveal cracks in this region, the licensee is proposing on a one-time basis to revise the TS such that tubes found to contain flaws found in the lower 4-inches of the tubesheet region need not be plugged or repaired and that the lower 4-inch region be excluded from current inspection requirements. In addition, the licensee proposed new requirements defining the minimum inspection scope with rotating coils for the upper 17-inch of the tubesheet region and requiring that tubes with indications in this region be plugged or repaired on detection.

3.0 REGULATORY EVALUATION

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 coolant from the secondary coolant and the environment. For the purposes of this safety evaluation, tube integrity means that the tubes are capable of performing these 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" (GDC 15 and 31), shall be of "the highest quality standards practical" (GDC 30), and shall be designed to permit "periodic inspection and testing of important areas and features to assess their structural and leaktight integrity" (GDC 32). To this end, 10 CFR 50.55a(c)(1) 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(g)(3)(i) further requires, in part, that throughout the service life of a pressurized-water reactor (PWR) facility, ASME Code Class 1 components meet the 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 surveillance requirements 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 (SGTR) 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 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).

Under the plant TS SG surveillance program requirements, the licensee is required to monitor the condition of the SG tubing and to plug or repair tubes as necessary. Specifically, the licensee is required to perform periodic inspections of and to repair or remove from service by plugging all tubes found to contain flaws with sizes exceeding the acceptance limit, termed "plugging limit." The tube plugging limits were developed with the intent of ensuring that degraded tubes (1) maintain factors of safety against gross rupture consistent with the plant design basis (i.e., consistent with the stress limits of the ASME Code, Section III) and (2) maintain leakage integrity consistent with the plant licensing basis while, at the same time, allowing for potential flaw size measurement error and flaw growth between SG inspections. The required frequency and scope of tubing examinations and the tube plugging limits are specified in TS 5.5.9, "Steam Generator (SG) Tube Surveillance Requirements."

The subject TS amendment request concerns the portions of the tubing that are subject to the TS SG tube surveillance requirements, including any necessary plugging or repairs, and the inspection methods to be employed. TS 5.5.9 defines a tube inspection as an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg. This includes the full length of tubing within the thickness of the tubesheet on the hot leg side.

The proposed license amendment would limit the required inspections, plugging and repairs in the 21-inch thick tubesheet region to the upper 17-inches of the tubesheet region and is conceptually similar to permanent amendments approved by the NRC staff for a number of plants. Examples include the F* criteria approved for Westinghouse SGs where the tubes were hard roll expanded inside the tubesheet and the W* criteria approved for plants where the tubes were explosively expanded against the tubesheet. In the case of the F* criteria, the required inspection zone was limited to approximately the upper 1.5-inch zone below the TTS. The W* criteria required an inspection zone extending approximately 8-inches below the TTS. The larger required inspection zone for W* relative to F* is that the explosively expanded joints do not exhibit as much residual interference fit as do hard rolled joints. The proposed license amendment for Byron would be the second to exclude a portion of tubing in the tubesheet from TS SG inspection and plugging and repair requirements for plants where the tubes are hydraulically expanded against the tubesheet (Braidwood was the first, April 25, 2005, ML051110573).

4.0 <u>TECHNICAL EVALUATION</u>

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 the ASME Code, Section III, 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 design basis accident 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 leaktight.

The licensee, in effect, is proposing on a one-time basis to exempt the lower 4-inches of the 21-inch deep tubesheet region from a tube inspection (see proposed change to TS 5.5.9.e.8, "Tube Inspection") and to exempt tubes with flaw indications in the lower 4-inch zone from the need to plug or repair (see the first of two proposed new paragraphs for TS 5.5.9.e.6, "Plugging or Repair Limit"). The latter part of this proposal (i.e., to exempt tubes from plugging or repair) 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 assumed to be hydraulically expanded against tubesheet over the top 17-inches of the tubesheet region. Under this proposal, no credit is taken 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 assumed not to exist.

The regulatory standard by which the NRC staff has evaluated the subject license amendment is that the amended technical specifications should continue to ensure that tube integrity will be maintained. This includes maintaining structural safety margins consistent with the plant design basis as embodied in the stress limit criteria of the ASME Code, Section III as is discussed in Section 4.1 below. In addition, this includes limiting the potential for accident induced primary to secondary leakage to values not exceeding those assumed in the licensing basis accident analyses. Maintaining tube integrity in this manner ensures that the amended TS are in compliance with all applicable regulations. The NRC staff's evaluation of joint structural integrity and leakage integrity is discussed in Sections 4.1 and 4.2 of this safety evaluation, respectively.

The licensee has also proposed on a one-time basis to add a specific requirement to perform a rotating coil examination of a 20 percent sample of tubes in the upper 17-inch span of the tubesheet region, including a 20 percent sample of the bulges and over-expansions within this 17-inch zone (see proposed addition to TS 5.5.9.b, "SG Tube Sample Selection and Inspection"). The NRC staff has no objection to this new requirement since the 20 percent sample size (which is based on industry guidelines) exceeds current TS minimum sample size requirements (i.e., 3 percent) and, thus, is more conservative than the currently applicable requirement. Should these inspections identify flaw indications, additional inspection samples may be required as defined in the current TS (industry guidelines contain more conservative sample expansion criteria).

To clarify the above proposed requirement, the licensee has proposed adding definitions of "bulge" and "over-expansion" as discussed in Section 3 of this safety evaluation. The licensee states that the definition of "bulge" (i.e., tube diameter variation producing an 18 volt bobbin response) is approximately equivalent to the voltage response of a 1-mil over-expansion and is just above the lowest voltage that can be reasonably differentiated from noise. The definition of "over-expansion" (i.e., tube diameter deviation of 1.5 mils or greater) is intended to ensure that tube diameter deviations of this magnitude are inspected, irrespective of voltage amplitude. The NRC staff notes that the main value of these definitions is that they clarify exactly how the proposed rotating coil sampling plan for bulges and over-expansions is to be implemented. Thus, the NRC staff finds the proposed definitions to be acceptable.

The licensee is also proposing on a one-time basis to plug or repair on detection any flaw indication found in the upper 17-inch region of the tubesheet region of the tubes, irrespective of whether the flaw exceeds the TS 40 percent plugging limit (see proposed second new paragraph for TS 5.5.9.e.6, "Plugging or Repair Limit"). The NRC staff finds this acceptable since it is more conservative than current TS 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 pull out under tube end cap pressure loads and in resisting primary to secondary leakage between the tube and tubesheet.

The current TS permit sleeving repairs in lieu of removing tubes from service by plugging. However, the integrity of the sleeve joints depends on the subject tube being found to be free of detectable flaws at the location of the sleeve joints. Because the existence of flaws in the lower 4-inches of the tubesheet region cannot be precluded, the licensee made a regulatory commitment in its May 24, 2005 letter as follows: "During Refueling Outage 12 and the subsequent operating cycle, no SG tube sleeves that have a connecting joint below 17-inches below from the top of the hot leg tubesheet will be installed."

4.1 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 design basis accident 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 that could produce pullout derives from the pressure end cap loads due to the primary to secondary pressure differentials associated with normal operating and design basis accident conditions. The licensee's contractor, Westinghouse, determined the required engagement distance on the basis of maintaining a factor of three against pullout under normal operating conditions and a factor of 1.4 against pullout under accident conditions. Pullout was conservatively treated as tube slippage relative to the tubesheet of 0.25-inches. The NRC staff concurs that these are the appropriate safety factors to apply to demonstrate structural integrity. As documented in detail in a safety evaluation accompanying the NRC staff's approval of new performance based SG TS for Farley Units 1 and 2 (Reference: Letter, Sean Peters, NRC, to L. M. Stinson, Vice President, Southern Nuclear Operating Company, "Joseph M. Farley Nuclear Plant, Units 1 and 2, re: Issuance of Amendments to Facilitate Implementation of Industry Initiative NEI 97-06, Steam Generator Program Guidelines," dated September 10, 2004, ADAMS Accession No. (ML042570427)), the NRC staff has concluded that these safety factor criteria are consistent with the design basis; namely the stress limit criteria in the 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: (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 concluded that the required engagement distances to ensure the safety factor criteria against pullout are achieved vary from 3 to 8.6 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.

The NRC staff has not reviewed the Westinghouse analyses in detail and, thus, has not reached a conclusion with respect to whether 3 to 8.6 inches of engagement (termed H* criterion by Westinghouse) is adequate to ensure that the necessary safety margins against pullout are maintained. The licensee, therefore, is proposing on a one-time basis to inspect the tubes in the tubesheet region such as to ensure a minimum of 17 inches of effective engagement, well in excess of the 3 to 8.6 inches that the Westinghouse analyses indicate are needed. Based on the following considerations, the NRC staff concludes the proposed 17-inch engagement length is clearly acceptable to ensure the structural integrity of the tubesheet joint.

- Pullout tests demonstrate that the radial contact pressure produced by the hydraulic expansion alone is such as to require an engagement distance of 6-inches to ensure the appropriate safety margins against pullout. This estimate is a mean minus one standard deviation estimate based on nine pullout tests. This estimate ignores the effect on needed engagement distance from differential thermal expansion, internal primary pressure in the tube, and tubesheet bore dilations associated with tubesheet bow.

- Radial differential thermal expansion between the tube and tubesheet under hot operating and accident conditions will act to further tighten the joint (i.e., increase radial contact pressure) and to reduce the necessary engagement distance relative to room temperature conditions. The radial differential thermal expansion arises from the fact that the Alloy 600 tubing has a slightly higher (by 6 percent) coefficient of thermal expansion than does the SA-508 Class 2a tubesheet material and that the tubes are a little hotter than the tubesheet.

- The internal primary pressure inside the tube under normal operating and accident conditions also acts to tighten the joint relative to unpressurized 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 top of the tubesheet 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 to of the tubesheet), 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 radial differential thermal expansion and 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 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 pull out tests. Thus, the 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 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 tubing 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 limiting condition for operation (LCO) limits. However, it must also be demonstrated that the proposed TS changes do not create the potential for leakage during design basis accidents that may exceed values assumed in the licensing basis accident analyses. The licensee states that this is ensured by limiting primary to secondary leakage to 0.5 gallons per minute (gpm) in the faulted SG during a MSLB.

To support its H* criterion (discussed above), Westinghouse has developed a detailed leakage prediction model, which considers the resistance to leakage from cracks located within the thickness of the tubesheet. The NRC staff has not reviewed or accepted this model. For the proposed one-time 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 (i.e., 150 gallons per day (gpd)) under normal operating conditions, Westinghouse estimates that leakage would not be expected to exceed 0.21 gpm (300 gpd), significantly less than the 0.5 gpm assumed in the licensing basis accident analyses for MSLB.

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 1200 and 1400 psi and accident differential pressures on the order of 2560 to 2650 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 eight inch zone in the upper 17 inches of the tubesheet where there is an increase in joint contact pressure due to higher primary pressure inside the tube and changes in tubesheet bore dilation along the length of the tubes. In Section 4.1 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 pressurized 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 Westinghouse estimate that contact pressures, and, thus, leak flow resistance, always increases over at least an 8-inch distance appears reasonable to the NRC staff.

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 assessment. 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 one-time exclusion 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, ensures that the structural and leakage integrity of the tube-to-tubesheet joint will be maintained with structural safety margins consistent with the 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. Therefore, the NRC staff concludes that the proposed amendment is acceptable.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Illinois 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 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 (70 FR 38712, 38718). 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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