Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-055

March 28, 2016

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 8, Response to Request for Additional Information**

References:
1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)

2. Letter from NRC to TVA, “Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF6741, MF6742, and MF6743),” dated February 18, 2016 (ML16041A307)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. During their technical review of the LAR, the Nuclear Regulatory Commission (NRC) identified the need for additional information. The Reference 2 letter provided an NRC Request for Additional Information (RAI) related to the residual heat removal heat exchanger performance monitoring program. The due date for the response to the NRC RAI provided by the Reference 2 letter is March 14, 2016. However, due to the need to perform additional analysis to support the development of the response to this RAI, the submittal date for this response was extended to March 28, 2016, per communications with the NRC Project Manager. The enclosure to this letter provides the response to the RAI included in the Reference 2 letter.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 28th day of March 2016.

Respectfully,

J. W. Shea Digitally signed by J. W. Shea
DN: cn=J. W. Shea, o=Tennessee Valley Authority, ou=Nuclear Licensing, email=jwshea@tva.gov, c=US
Date: 2016.03.28 16:40:25 -04'00'

J. W. Shea
Vice President, Nuclear Licensing

Enclosure: Response to NRC Request for Additional Information SCVB-RAI 1

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health

ENCLOSURE

Response to NRC Request for Additional Information
SCVB-RAI 1

ENCLOSURE

SCVB-RAI-1

During the review of Attachment X of the LAR regarding National Fire Protection Association (NFPA) 805 Transition Report (Reference 1), the NRC staff requested in an RAI (SCVB-RAI-5) that TVA describe the revised BFN, Units 1, 2, and 3, residual heat removal (RHR) heat exchanger performance monitoring program, which will assure that its fouling factor and tube plugging would not exceed their worst values assumed in calculating a K-value of 284.5 British thermal unit (BTU)/sec-degrees Fahrenheit (°F). In response to this RAI (Reference 2), TVA stated, "The revised performance monitoring program has not been developed at this time ... ", and made a commitment to revise the program that monitors the RHR heat exchanger performance.

In the approval of the NFPA 805 LAR, the NRC imposed the following license condition, which was accepted by TVA as implementation Item No. 49 in Reference 3:

> *Revise the program that monitors BFN Residual Heat Removal (RHR) heat exchanger performance for consistency with the assumptions of the NFPA 805 Net Positive Suction Head (NPSH) analysis. The monitoring program shall include verification that the tested worst fouling resistance, with measurement uncertainty added, of all BFN Units 1, 2, and 3 RHR heat exchangers is less than the design value of 0.001517 hr-ft^2-°F/BTU and the worst tube plugging is less than 4.57 percent.*

In Attachment 6 (Reference 4) and Attachment 39 (Reference 5) to the extended power uprate (EPU) LAR, at the EPU design-basis accident (DBA) loss-of-coolant accident (LOCA) statepoint, the RHR heat exchanger K-value for one heat exchanger is reported to be 265 BTU/sec-°F for a design fouling resistance of 0.001521 hr-ft^2-°F/BTU, which supersedes the fouling factor of 0.001517 hr-ft^2-°F/BTU reported in the NFPA 805 LAR.

Section 2.1 of Reference 5 provides the following EPU RHR heat exchanger K-values used in the analyses:

- *265 BTU/sec-°F (DBA-LOCA, Small Break LOCA, Loss of Shutdown Cooling, Stuck Open Relief Valve and SBO [Station Blackout]), 302 BTU/sec-°F (Shutdown of Non-Accident Unit), and 287 BTU/sec-°F (fire event defense-in-depth demonstration case) are based on the EPU design fouling resistance, 0.001521 hr-ft^2-°F/BTU.*

- *307 BTU/sec-°F (fire event licensing basis) is based on the EPU nominal fouling resistance, 0.001097 hr-ft^2- °F/BTU.*

- *277 BTU/sec-°F for the ATWS-MSIVC-EOC event corresponds to a nominal fouling resistance of 0.001220 hr-ft^2-°F/BTU.*

Describe the performance monitoring program to monitor the as-found worst RHR heat exchanger fouling factor and plugged tubes. As mentioned above, the description of this program was previously requested for the NFPA 805 LAR approval and is being again requested for the EPU LAR submittal. The monitoring program must verify the EPU design

fouling resistance, 0.001521 hr-ft^2-°F/BTU and EPU nominal fouling resistance and 0.001097 hr-ft[^{2}]-°F/BTU, as given above.

The description of the program should include the following:

- *(a) Scope of monitoring*
- *(b) Frequency of monitoring*
- *(c) Acceptance criteria for the fouling factor should be less than nominal fouling resistance of 0.001097 hr-ft^2-°F/BTU (for fire event) with uncertainty included*
- *(d) Acceptance criteria for plugged tubes - must be less than or equal to 4.57 percent tubes*
- *(e) Accepted industry standards and guidelines used for heat exchanger performance testing*
- *(f) Test setup*
- *(g) Instrumentation with its accuracy*
- *(h) Method of suppression pool heatup*
- *(i) Data acquisition system*
- *(j) Uncertainty analysis*
- *(k) Data reduction method for calculation of the fouling factor*
- *(l) Method of as-found heat-exchanger inspection for determining the number of plugged tubes and the effective heat transfer area*

<u>REFERENCES</u>

1 *Tennessee Valley Authority (TVA), Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3, "Transition to 10 CFR 50.48(c) - NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition, Transition Report," dated March 2013 (ADAMS Accession Number ML13092A392).*

2 *Letter from TVA to NRC, dated June 13, 2014, "Response to NRC Request for Additional Information Regarding the License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MF1185, MF1186, and MF1187) - Attachment X and Fire Modeling" (ADAMS Accession Number ML14167A175).*

3 *Letter from TVA to NRC, dated October 20, 2015, "Update to License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MF1185, MF1186, and MF1187) - Revised Implementation Item 49" (ADAMS Accession No. ML15293A527).*

4 *Attachment 6 to EPU LAR, NEDC-33860P, Revision 0, "Safety Analysis Report for Browns Ferry Nuclear Plant, Units 1, 2, and 3, Extended Power Uprate (proprietary)" (ADAMS Accession No. ML15282A264 (non-public)).*

5 *Attachment 39 to EPU LAR, "RHR Heat Exchanger K-values Utilized in EPU Containment Analyses" (ADAMS Accession No. ML15282A235).*

TVA Response:

General Description:

Beginning in January 2012, Residual Heat Removal (RHR) heat exchanger performance tests were performed in conjunction with quarterly Reactor Core Injection Cooling (RCIC) surveillance testing (see item h, below, for further details). The RHR heat exchanger testing involves installation of temporary temperature and temporary differential pressure instruments (connected to instrument taps from permanently installed Residual Heat Removal Service Water (RHRSW) flow orifices or RHR flow nozzles) to collect the data necessary to compute heat exchanger tube side and shell side heat transfer rates. The RHR heat exchanger testing uses a Tennessee Valley Authority (TVA) approved procedure to perform the test. Under contract, an outside vendor operating under a 10 CFR 50 Appendix B Quality Assurance (QA) program provides the test instrumentation, including data acquisition system, collects and processes the data, and provides test reports documenting the results. The data analysis and preparation of vendor test reports are performed by a vendor also operating under a 10 CFR 50 Appendix B Quality Assurance Program in accordance with approved procedures. The procedures include steps to compare process and tube side heat transfer rates and to statistically evaluate test data such that results conservatively account for the uncertainties associated with each test. Thus, the accuracy of each test, which varies from one test to another, is reflected in the test results which are then compared to the acceptance criteria.

This RAI response details how the Browns Ferry Nuclear (BFN) Generic Letter (GL) 89-13 program is expected to be changed once the National Fire Protection Association (NFPA) 805 license condition becomes effective. The GL 89-13 program is currently scheduled to be revised by June 16, 2016, to support NFPA 805 transition implementation. TVA will inform the NRC when the GL 89-13 program has been revised.

The response to each specific item in the NRC RAI is provided below:

(a) The Current Licensed Thermal Power (CLTP) scope of monitoring will be established once the NFPA 805 license condition is implemented (on or before June 16, 2016). Extended Power Uprate (EPU) implementation will not require any changes to the CLTP scope of monitoring. In both cases, the scope of monitoring will include verification that: (1) tested worst fouling resistance of all BFN Units 1, 2, and 3 RHR heat exchangers is less than the design value acceptance criteria; and (2) worst tube plugging is less than the tube plugging acceptance criteria.

(b) An RHR heat exchanger performance testing program will be maintained through the BFN Preventive Maintenance (PM) program. Previously (prior to June 16, 2016), the GL 89-13 commitment for the RHR heat exchangers was met through BFN PM Program routine cleaning and inspection. Current plans are to have each RHR heat exchanger tested at least once by June 16, 2016. Thereafter, each RHR heat exchanger will be tested periodically at an interval that initially will not exceed five years. The performance testing PMs provide criteria for reassessing the performance testing frequency based upon test results. Additionally, the heat exchangers will be cleaned on an 8-year frequency. This 8-year cleaning frequency is based on supporting eddy current testing, which is a PM requirement outside of the BFN GL 89-13 program. More frequent cleanings will occur if the fouling rate (as trended) indicates the need to take corrective actions in order to maintain the heat exchanger condition within the fouling resistance acceptance criteria (see item (c) response, below).

CLTP or EPU	Frequency of Monitoring - Performance Testing
CLTP (expectation as of June 16, 2016)	Each RHR heat exchanger will have been performance tested at least once and will be tested periodically at an interval that initially will not exceed five years.
EPU Implementation	Each RHR heat exchanger will have performance testing at a periodicity determined by RHR heat exchanger test results and the fouling rate trended.

CLTP or EPU	Frequency of Monitoring - Visual Inspection and Cleaning
CLTP (expectation as of June 16, 2016)	Each RHR heat exchanger will be cleaned on an 8-year frequency.
EPU Implementation	Each RHR heat exchanger will be cleaned once every 8-years or more frequently if the trended fouling rate indicates the need to take corrective actions in order to maintain the heat exchanger condition within the fouling resistance acceptance criteria.

(c) CLTP fouling resistance acceptance criterion will be established upon implementation of the NFPA 805 license condition (on or before June 16, 2016). Upon EPU implementation, the fouling resistance acceptance criterion will be changed, as described in EPU License Amendment Request (LAR) Attachment 39. Specifically, the NFPA 805 design fouling resistance of 0.001517 hr-ft^2-°F/Btu (corresponding to Design Basis Accident-Loss of Coolant Accident (DBA-LOCA) event with RHR heat exchanger K of 265 Btu/sec-°F) will be replaced with the EPU design fouling resistance of 0.001521 hr-ft^2-°F/Btu (corresponding to EPU DBA-LOCA event with RHR heat exchanger K of 265 Btu/sec-°F).

DBA-LOCA event

CLTP or EPU	Fouling Resistance Acceptance Criteria
EPU Implementation	EPU Design (DBA-LOCA event): 0.001521 hr-ft^2-°F/Btu*

*The EPU DBA-LOCA design and licensing basis minimum required heat removal rate (System Operability Limit per American Society of Mechanical Engineers (ASME) Operation and Maintenance (OM)-2015, Part 21, Section 9.1) is 80,136,000 Btu/hr per heat exchanger, with two heat exchangers in service. BFN design calculations establish the RHR heat exchanger testing program fouling resistance acceptance criterion based on the EPU DBA-LOCA design and licensing basis minimum required heat removal rate.

The RHR heat exchanger performance test result fouling resistance (including test uncertainty) will be compared to the DBA-LOCA event acceptance criterion (fouling resistance of 0.001521 hr-ft^2-°F/Btu). This acceptance criterion was determined from a deterministic containment analysis based on conservative inputs. Upon EPU

implementation, BFN will follow the guidance from the ASME OM-2015, Part 21, Section 9.1, System Operability Limits, for the DBA-LOCA event. Specifically, the EPU DBA-LOCA design and licensing basis minimum required heat removal rate, as shown in EPU LAR Attachment 39, Table 4, will be the System Operability Limit. Additionally, RHR heat exchanger performance test fouling resistance, including test uncertainty, will be trended for comparison to the DBA-LOCA event fouling resistance acceptance criterion, in a manner consistent with ASME OM-2015, Part 21, Section 6.10, except for the second paragraph of Section 6.10.2. Because the BFN testing program will compare the test results to the acceptance criteria at the time the program is established, BFN will take specific exception to the second paragraph of Section 6.10.2 which requires "trending these parameters for a minimum of three test or monitoring points" prior to comparison to the applicable acceptance criteria (i.e., trending will be performed prior to having a minimum of three test or monitoring points). This is the only exception to Section 6.10.

Fire Event

CLTP or EPU	Fouling Resistance Acceptance Criteria
CLTP (expectation as of June 16, 2016)	CLTP Fire event: 0.001517 hr-ft^2-°F/Btu
EPU Implementation	EPU Fire event: 0.001097 hr-ft^2-°F/Btu*

*The EPU fire event design and licensing basis minimum required heat removal rate is 128,203,200 Btu/hr with one heat exchanger in service. BFN design calculations establish the RHR heat exchanger testing program fouling resistance acceptance criterion for the fire event at EPU conditions based on the EPU fire event design and licensing basis minimum required heat removal rate.

The RHR heat exchanger performance test result nominal fouling resistance (including test uncertainty) will be compared to the fire event acceptance criterion (fouling resistance of 0.001097 hr-ft^2-°F/Btu*).

(d) The CLTP allowable tube plugging acceptance criterion (4.57%) applicable to the NFPA 805 licensing condition will be established in applicable implementing program procedures once the NFPA 805 license condition is implemented (on or before June 16, 2016). Upon EPU implementation, BFN design calculations will establish the RHR heat exchanger testing program tube plugging limit acceptance criterion (4.57%).

(e) Accepted industry standards and guidelines used for heat exchanger performance testing will be identified in applicable CLTP program documents once the NFPA 805 license condition is implemented (on or before June 16, 2016). EPU will not require any change from the standards and guidelines used for CLTP heat exchanger performance testing.

CLTP or EPU	Accepted Industry Standards/Guidelines
CLTP (expectation as of June 16, 2016)	Performance testing will be conducted consistent with the guidance described in Electric Power Research Institute (EPRI) 3002005340, Service Water Heat Exchanger Testing Guidelines, May 2015. Testing performed between January 2015 and May 2015 was conducted consistent with the guidance provided in the previous version of this document, EPRI TR-107397, Service Water Heat Exchanger Testing Guidelines, Final Report, March 1998. Testing conducted in January 2012 also followed the EPRI TR-107397 guidelines as well as EPRI NP-7552, "Heat Exchanger Performance Monitoring Guidelines," dated December 1991.
EPU Implementation	Performance testing will be conducted consistent with the guidance described in EPRI 3002005340, Service Water Heat Exchanger Testing Guidelines, May 2015. Parameter (fouling resistance) trending and comparison to DBA-LOCA event acceptance criteria will be performed consistent with the guidance provided in ASME OM-2015, Part 21, Section 6.10, Parameter Trending, except as noted in response (c).

(f) Test set-up included installation of temporary surface mounted temperature sensors on the heat exchanger process (RHR) and cooling water (RHRSW) inlet and outlet pipes. The piping insulation was removed and eight temporary surface-mounted temperature sensors were uniformly spaced at 45° increments around the circumference of each outlet pipe. Piping insulation was also removed from each inlet pipe and four temporary surface-mounted temperature sensors were uniformly spaced at 90° increments around the circumference of each inlet pipe. The pipe insulation was then reinstalled over the temporary surface-mounted temperature sensors to reduce the influence from external environmental conditions. The temporary surface-mounted temperature sensor leads were bundled and routed to the data acquisition unit.

Dimensions of the system piping where RHRSW and RHR temperature sensors were mounted are contained in the detailed vendor test report. RHRSW inlet temperature sensors were mounted on 16" OD, 0.375" wall thickness, carbon steel pipe. RHRSW outlet temperature sensors were mounted on 12.75" OD, 0.375" wall thickness, carbon steel pipe. RHR inlet and outlet temperature sensors were mounted on 20" OD, 0.50" wall thickness, carbon steel pipe.

Temporary differential pressure instruments were connected to instrument taps from permanently installed RHRSW flow orifices and RHR flow nozzles.

Future RHR heat exchanger performance testing will be performed in a manner similar to or the same as that described above and performed to date, or in a manner that is consistent with the EPRI guidance identified in response (e), above.

(g) Temporary test instrumentation (e.g., surface-mounted temperature sensors, delta-P meters, current converter and data acquisition system) and thus, the associated instrumentation accuracy, is provided to BFN under contract from an outside vendor where 10 CFR Part 50 Appendix B and 10 CFR Part 21 apply. The vendor's Quality Assurance System complies with applicable requirements of International Standardization Organization (ISO)/International Electrotechnical Commission (IEC)-17025-2005, American National Standards Institute (ANSI)/National Conference of State Legislatures (NCSL) Z540-I-1994 and ISO 9001: 2008. The instruments are calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or compared to nationally or internationally recognized consensus standards. The reported calibration uncertainty has a confidence level of 95% (k=2). The temporary surface-mounted temperature sensors used during the tests that have been performed to date had a calibration accuracy of 0.1°F. Calibration certificates for the pre-test and post-test calibrations are included in the vendor test report.

Temporary delta-P meters were used to record the flow rates for RHR and RHRSW. The meters had a pre-test and post-test accuracy of 0.05% of full scale. The composite systematic uncertainty for the instruments used in measurement of RHRSW and RHR flow rates for the RHR heat exchanger performance tests performed since January 2012 is documented in each vendor test report. This value was calculated using 95% confidence analysis techniques. The resulting composite systematic uncertainty from each test for both RHRSW and RHR flow rates has been less than ±5% of measured flow.

Supplied temporary test instrumentation and associated instrumentation accuracy meets the Industry Standards/Guidelines identified in response (e), above. Specifically, EPRI 3002005340, Section 1.6.9 states, "ASME PTC 12.5, Single Phase Heat Exchangers was revised in 2005 and provides comprehensive guidance to plan, conduct and analyze results for accurate performance tests of single phase heat exchangers. The Code details information for calculation techniques and methods to determine steady state performance at both test conditions and reference conditions. Guidelines are also provided for instrumentation and accuracy." ASME PTC 12.5, Section 3.1.1 states, "As a benchmark, the calibration uncertainty for temperature measurements shall be less than ±0.2°F (±0.1°C), the total flow measurement uncertainty shall be less than ±5% of measured flow…" The instrumentation used in the tests performed to date meets these guidelines.

Installation of temporary test instrumentation is performed under an approved TVA procedure using the BFN work order process. Future RHR heat exchanger performance testing is expected to be performed in a manner similar to or the same as that described above and performed to date.

(h) One of the attributes of an effective RHR heat exchanger performance test is to maximize the heat exchanger heat removal rate. This requires maximizing the difference between the RHR (heat exchanger shell side) inlet temperature and the RHRSW (heat exchanger tube side) inlet temperature. The RHR (heat exchanger shell side) inlet temperature is dependent upon the suppression pool (torus) temperature while the RHRSW (heat exchanger tube side) inlet temperature is dependent upon the ultimate heat sink (river) temperature. These water bodies experience a maximum temperature differential during winter months, with a reduced temperature difference in spring and fall months, and a minimum temperature differential during summer months. Consequently, the best time of the year for maximizing the heat load on the RHR heat exchanger is to perform the test during winter months.

Beginning January 2012, RHR heat exchanger testing has been performed in accordance with an approved TVA procedure in conjunction with quarterly RCIC system surveillance testing. The intent of performing these tests in a back-to-back fashion was to allow the heat input rate from the RCIC turbine exhaust to the suppression pool (torus) to be matched to the removal rate from the suppression pool through the RHR heat exchanger while in the suppression pool cooling mode of operation. A perfect match of the heat input and removal rates would result in no change to the suppression pool temperature over the duration of the test data collection period. This condition would result in optimal steady state RHR (heat exchanger shell side) inlet temperatures during the test and would also serve to reduce the uncertainty associated with the test data. However, in practice, it is not feasible to match the heat input and heat removal rates exactly. Consequently, during the test data collection period there is some suppression pool heating or cooling, even though establishment of test conditions matches heat input and heat removal rates to the extent practical. In conclusion, there is actually no intent to change the suppression pool temperature during the RHR heat exchanger test data collection period.

Future RHR heat exchanger performance testing will be performed in a manner similar to or the same as that described above and performed to date.

(i) The data acquisition system for all tests performed since January 2012 was provided to TVA by an outside vendor operating under their own 10 CFR 50 Appendix B Quality Assurance program. This vendor provided the test instrumentation, including data acquisition system. The test instrumentation and data acquisition system is capable of instrumenting two heat exchangers at the same time and still have spares. All instruments and software are labeled and configured for specific use in each test location. This system complies with the requirements listed in the EPRI document TR-107397. A data acquisition software package works with the heat exchanger instrumentation system and produces data files that may be loaded directly into PROTO-HX. Personal computers with data collection software are provided by the vendor. The data collection software is written and validated under the vendor software Quality Assurance program. Time stamped data is collected from each sensor.

Future RHR heat exchanger performance testing will be performed in a manner similar to or the same as that described above and performed to date, or in a manner that is consistent with the EPRI guidance identified in response (e), above.

(j) The RHR heat exchanger performance testing that has been performed at BFN since January 2012 has used an outside vendor operating under a 10 CFR 50 Appendix B Quality Assurance program to provide the test instrumentation, collect and process the data, and provide test reports documenting the results. The data analysis and preparation of vendor test reports are performed by a vendor also operating under a 10 CFR 50 Appendix B Quality Assurance Program in accordance with approved procedures that include steps to compare process and tube side heat transfer rates and to statistically evaluate test data such that results conservatively account for the uncertainties associated with each test. The method of calculation follows the EPRI guidelines (see response (e), above) in terms of determining the uncertainty contributors of precision and bias errors for thermal performance test evaluations. The uncertainty analysis methodology in PROTO-HX determines the sensitivity coefficients through a numerical approach using the central differencing method (i.e., symmetric uncertainties). The EPRI guideline (see response (e), above) provides an overview of this approach. The variables considered are the test data (flow rates and temperatures) and the film coefficients.

Future RHR heat exchanger performance testing will be performed in a manner similar to or the same as that described above and performed to date.

(k) The data reduction method for calculating the fouling resistance involves averaging the data from the RHR heat exchanger test to identify nominal values for each parameter. These nominal values are then analyzed to determine the condition of the heat exchanger with respect to the overall fouling factor. Further analysis of the test data identifies the uncertainty in each parameter measurement. These uncertainties are then used to establish the overall uncertainty in the test result. The test result is then compared to the acceptance criterion to determine if the test is satisfactory.

The data reduction is performed by the vendor under the same processes as described in item (j), above. In the testing performed to date, the vendor calculation follows the heat transfer test method using the heat transfer at design limiting conditions as the performance parameter. This method is outlined in EPRI TR 107397, "Service Water Heat Exchanger Testing Guidelines," dated March 1998.

These initial testing results (vendor test reports) will be revised to recompute the performance parameter, including the performance parameter (fouling resistance) uncertainty, so as to report results consistent with the units specified in the NFPA 805 license condition for the fouling resistance, hr-ft^2-°F/Btu. Future data reduction methods for calculating the fouling resistance both prior to and following EPU implementation will follow the same or similar data reduction method for calculating the fouling resistance or in a manner that is consistent with the EPRI guidance identified in response (e), above.

(l) In the context of the "method of as-found heat-exchanger inspection for determining the number of plugged tubes and the resulting effective heat transfer area," it is noteworthy how this information actually impacts the heat exchanger post-test analysis. The vendor test reports contain the following conservative assumption: "It is assumed that all tubes were unobstructed during the test (i.e., none of the tubes were plugged by macro fouling during the test). It is an inherent part of the PROTO-HX method of analysis to distribute the tube-side flow equally to all tubes and to use the specified heat transfer area in the fouling calculation. This assumption is acceptable since lost area due to unknown macrofouling will show up as extra fouling resistance."

The method of as-found heat-exchanger inspection for determining the number of unavailable tubes and the effective heat transfer area is performed in accordance with a TVA procedure. An attachment to the procedure provides a GL 89-13 Heat Exchanger Visual Inspection and Evaluation Form. The form requires recording the number of tubes plugged, the number of tubes fully blocked (>90%), and the number of tubes partially obstructed (75% - 90%). Guidance for determining the number of tubes equivalent blocked is that tubes found with >90% of the area obstructed are considered fully blocked and 50% of the tubes with 75% to 90% of the area obstructed are considered fully blocked. The acceptance criterion is the number of tubes plugged, fully blocked or equivalent blocked must be less than the maximum plugging limit. This information on as-found potential tube blockage is only applicable for consideration in determining heat exchanger past-operability for an event where the potential tube blockage was introduced into the system since the performance of the last heat exchanger test. In some cases, this same as-found blockage could have been present during previous heat exchanger testing. The consideration of the effects of potential blockages inside the heat exchanger prior to the last heat exchanger performance test is addressed in the first paragraph of this response (item (I)).

EPU implementation will not change the method of as-found heat-exchanger inspection for determining the number of unavailable tubes and the effective heat transfer area. However, upon EPU implementation, design basis calculations will be revised to identify, for any given fouling resistance, the maximum allowable number of tubes that are unavailable and still meet the DBA-LOCA system operability limit minimum heat removal requirement. This determination will facilitate a more immediate assessment of the as-found condition of any RHR heat exchanger where the fouling resistance is known or can be projected based on the fouling rate and the as-found number of tubes determined to be fully blocked from the as-found heat exchanger inspection.