



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
RELATED TO AMENDMENT NO. 213 TO FACILITY OPERATING LICENSE NO. DPR-668

TENNESSEE VALLEY AUTHORITY  
BROWNS FERRY NUCLEAR PLANT, UNIT 3

DOCKET NO. 50-296

1.0 INTRODUCTION

By letter dated June 2, 1995, the Tennessee Valley Authority (TVA), proposed license amendments to the Custom Technical Specifications (CTS) for the Browns Ferry Nuclear Plant, Units 1, 2, and 3, to incorporate changes required to implement design changes to upgrade the existing analog power monitoring system in the three Browns Ferry units with a General Electric Company (GE) Digital Nuclear Measurement Analysis and Control Power Range Neutron Monitor System (NUMAC-PRNMS), including an Oscillation Power Range Monitor (OPRM) function. Changes to thermal limits specifications were also proposed to implement average power range monitor (APRM) and rod block monitor (RBM) technical specification improvements, and maximum extended load line limit analyses.

TVA submitted a revision to the original application on March 6, 1997, and on April 11, 1997, TVA proposed the same amendment in the Improved Standard Technical Specification (ISTS) format. Supplemental information was provided by letters dated May 13 and August 20, 1997, and March 13, 1998. The revisions and supplemental information do not affect the staff's proposed finding of no significant hazards consideration finding.

The ISTS format, which is described in NUREG-1433, Revision 1, "Standard Technical Specifications for General Electric Boiling Water Reactors (BWR/4)," is supplemented by NEDC-32410P-A, Supplement 1, "Nuclear Measurement Analysis and Control Power Range Neutron Monitor (NUMAC-PRNM) Retrofit Plus Option III Stability Trip Function."

The NUMAC-PRNMS modification was implemented for Browns Ferry, Unit 2 during the September - October 1997 refueling outage, and NUMAC-PRNMS is scheduled to be implemented for Browns Ferry, Unit 3 during the September - October 1998 refueling outage. Unit 1 is in a non-operational status, and there is no specific plan to return the unit to service. The subject modifications will be installed at Unit 1 prior to restart.

The staff approved the proposed CTS changes for Browns Ferry, Unit 2 in Amendment No. 249 on September 11, 1997, and on July 14, 1998, the staff issued Amendment No. 253 which converted the Browns Ferry Unit 2 Technical Specifications from the CTS format to the ISTS format.

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## 2.0 BACKGROUND

The proposed changes reflect design changes that upgrade the existing analog power monitoring system in Browns Ferry Unit 3 with a GE Digital NUMAC-PRNMS, including an OPRM function.

By letter dated September 5, 1995, the U.S. Nuclear Regulatory Commission (NRC) staff approved GE licensing topical report (LTR) NEDC-32410P, "Nuclear Measurement Analysis and Control Power Range Neutron Monitor (NUMAC-PRNM) Retrofit Plus Option III Stability Trip Function." The staff review of this topical report determined that NEDC-32410P contains acceptable guidance for replacing the existing power range monitors in a boiling water reactor with a digital NUMAC-PRNMS. NEDC-32410P also contains guidance to ensure digital upgrade issues, relevant standards and guidelines, and technical specifications are adequately addressed.

TVA's proposed changes applicable to the APRM portion of the Browns Ferry Unit 3 Technical Specifications are to be implemented following installation of the NUMAC-PRNMS. The OPRM functions will be operated in the "indicate only" test mode for one fuel cycle. Following the NRC staff review and approval of the operating data, the OPRM trip function will be connected to the reactor protection system (RPS) channels, and OPRM-specific technical specification changes will be implemented. During this test period, the existing interim corrective actions for determining and mitigating power oscillations will remain in effect.

Using the existing local power range monitors (LPRM) and the recirculation coolant loop flows, the NUMAC-PRNMS provides APRM and OPRM trip signals to the RPS. The APRM system averages LPRM signals, processes flow signals from the reactor core recirculation flow instrumentation, and then compares the results to RPS trip set points. The OPRM detects and suppresses reactor core power instabilities using the Option III approach described in LTR NEDO-31960, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," dated June 1991, which has been approved by the NRC staff.

The GE NUMAC-PRNMS consists of four APRM channels and four voter channels. Trip signals from each of the four APRM channels are sent to all four voter channels. One voter module is dedicated to each RPS trip relay. A reactor trip occurs when two or more of the four APRM functions, or two or more of the four OPRM functions calculate a trip condition. The voters perform a vote of the OPRM channel trip outputs separate from the APRM trip outputs. For example, an OPRM trip in one channel and an APRM trip in another channel will not result in a reactor trip from two of four voters in a trip state.

## 3.0 EVALUATION

### 3.1 NUMAC-PRNMS

As stated in the staff's safety evaluation of NEDC-32410P, to receive NRC approval of a NUMAC-PRNMS installation, the licensee must confirm:

1. The applicability of NEDC-32410P, including clarifications and reconciled differences between the specific plant design and the topical report design descriptions;



2. The applicability of the BWR Owners' Group topical reports that address the NUMAC-PRNMS and associated instability functions, set points and margins;
3. Plant-specific revised technical specifications for the NUMAC-PRNMS functions are consistent with NEDC-32410P, Appendix H, and Supplement 1;
4. Plant-specific environmental conditions are enveloped by the NUMAC-PRNMS equipment environmental qualification values;
5. Administrative controls are provided for manually bypassing APRM/OPRM channels or protective functions and for controlling access to the APRM/OPRM panel and channel bypass switch, and
6. Any changes to the plant operator's panel have received human factors reviews per plant-specific procedures.

TVA's actions with regard to the above conditions are discussed in the following sections.

#### 3.1.1 Applicability of the NUMAC-PRNMS Design to the Browns Ferry Plant Design

The NRC staff compared the applicable Browns Ferry design features with the corresponding design features in LTR NEDC-32410P. The Browns Ferry units are GE BWR/4s, a BWR design addressed in the LTR. Consistent with the LTR system description, the six APRM channels currently used in the Browns Ferry will be combined into four 2-out-of-4 logic channels that will provide inputs through dedicated RPS channel voters to the four RPS channels.

Additionally, TVA is increasing the number of recirculation flow instrument channels from two total flow channels (four transmitters) to four channels (eight transmitters). These proposed design modifications conform to the NUMAC-PRNMS design description in NEDC-32410P, and are compatible with the existing plant neutron monitoring system and RPS. Therefore, the staff finds that the NUMAC-PRNMS design is applicable to the Browns Ferry units.

#### 3.1.2 PRNMS Instability Functions, Set Points, and Margins

TVA will test the PRNMS instability function (OPRM), including the adequacy of the set point values and margins during the first fuel cycle of OPRM operation, using the methodology described in LTR NEDO-32465-A, "BWR Owners' Group Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology and Reload Applications, dated August, 1995. At the end of the fuel cycle, following NRC staff review and approval of the operating data, the OPRM trip function will be connected to the RPS channels, and OPRM technical specification changes will be implemented. The staff approved the initial period for OPRM confirmatory testing in the safety evaluation of NEDC-32410P and, therefore, finds TVA's approach acceptable.

#### 3.1.3 Plant-Specific Revised Technical Specifications

The changes to the Browns Ferry Technical Specifications are discussed in Section 3.3.



### 3.1.4 Plant-Specific Environmental Conditions

On May 13, 1997, TVA provided the Browns Ferry Unit 3 plant-specific environmental conditions for temperature, humidity, pressure, and radiation. These environmental conditions are compared to the NUMAC-PRNMS environmental qualification values in the table below.

	BROWNS FERRY UNIT 3	NUMAC-PRNMS
Temperature	15.6°C (60°F) to 40°C (104°F)	5°C (41°F) to 50°C (122°F)
Humidity	10% to 90% RH	10% to 90% RH
Pressure	14.7 psia to 14.72 psia	13 psia to 16 psia
Radiation	1x10 <sup>-3</sup> Rads (carbon) dose rate 350 Rads (carbon) total integrated dose	1x10 <sup>-3</sup> Rads (carbon) dose rate 1000 Rads (carbon) total integrated dose

This table shows that the Browns Ferry environmental conditions are enveloped by the NUMAC-PRNMS qualification values and, therefore, are acceptable.

The staff reviewed the seismic response spectra for the Browns Ferry units and concludes that the Browns Ferry seismic qualification is within the NUMAC-PRNMS seismic qualification envelope and, therefore, is acceptable.

The approved LTR states that new equipment and plant modifications should not produce unacceptable levels of noise emissions that could adversely affect NUMAC equipment, or the licensee is to take action to prevent these emissions from reaching potentially sensitive equipment. These measures apply for both noise susceptibility and emissions. The Browns Ferry Unit 3 design procedures require that all digital equipment systems to be installed or used within the plant shall be evaluated for susceptibility and emissions of electromagnetic interference (EMI) in accordance with the NRC-approved Electric Power Research Institute Guideline TR-102323. The staff finds this approach acceptable for ensuring the EMI environment conforms to the requirements of General Design Criterion (GDC) 4 of 10 CFR Part 50 Appendix A. The staff reviewed TVA's evaluation of environmental conditions in the Browns Ferry units and concludes that the Browns Ferry environmental conditions are enveloped by the GE equipment qualification parameters established for the NUMAC-PRNMS modification.

As described in the approved LTR, the PRNMS uses the same panel interfaces as the existing power range monitor equipment. High frequency filters are installed on the ac power supply, and shielded cables for all signal leads will be used in lieu of testing non-safety equipment noise effects on the PRNMS.

The staff finds TVA's evaluation of the EMI environment and the measures taken to reduce adverse EMI affects to be an acceptable approach for ensuring the NUMAC-PRNMS EMI environment conforms to the requirements of GDC 4 for protection against adverse environmental effects.





### 3.1.5 Administrative Controls

In the safety evaluation of NEDC-32410P, the staff found acceptable the NUMAC-PRNMS design features that control access to set point adjustments, calibrations, and test points. Since TVA has not proposed design changes that would override these controls, the staff finds that TVA has acceptable controls for controlling access to the PRNMS panel and the APRM/OPRM channel bypass switch.

### 3.1.6 Confirmation of Human Factors Review

TVA has stated that the Browns Ferry Unit 3 design change process and implementing procedures require completion of a Human Factors Engineering (HFE) Process Checklist and performance of an HFE review of changes to the plant operator's panel. TVA has stated further that an HFE review per applicable Browns Ferry procedures of the proposed changes to the operator's panel will be performed, and documentation of that review will be included in the final design package for the PRNMS. The staff finds this commitment acceptable.

### 3.2 ARTS/MELLL

TVA also has proposed changes related to the implementation of APRM and RBM technical specification (ARTS) improvements recommended by GE and the proposed operation in an expanded core power/flow domain, the Maximum Extended Load Line Limit (MELLL) region. APRM and RBM set point changes required to implement the proposed ARTS/MELLL operation are included in the NUMAC PRNM design.

MELLL would permit:

1. Operation above the 100% (control) rod line below 100% flow, with operation permitted at 100% power down to 75% flow in the MELLL region, and
2. Operation with increased flow (to 105% at full power) in the increased core flow (ICF) region.

MELLL and ICF involve changes to the APRM rod block and thermal power scram set points.

ARTS involves:

1. Implementation of power and flow dependent fuel thermal limits to eliminate APRM trip set down,
2. Supports power dependent RBM trips rather than the current flow dependent trips,
3. Reconfiguration of LPRM inputs to the RBM and new trip logic, and
4. Redefinition of RBM operability requirements.

In support of its request, TVA has submitted a description and evaluation of the changes, the proposed new technical specifications, and GE report NEDC-32433P which describes the changes and presents the analysis and evaluations used to justify the changes for the Browns

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Ferry units, and operation with the revised analytical and physical systems and within the new limits resulting from the proposed changes.

These proposed changes for Browns Ferry are not unique or new for GE reactors. They have all become part of standard "Operating Flexibility Options" and are listed as such in the GE standard application for reactor fuel (GESTAR II). Extended operating regions, increased core flow have been approved on many BWRs over the past decade, and several ARTS upgrades have been reviewed and approved. The methodologies used for safety analyses involved in the justifications for the changes and the determination of new operating limits have been previously reviewed by the staff. The proposed new operating regions, and modes and limits of operation, and changes to the APRM and RBM systems are all bounded by changes previously approved for other BWRS.

The MELLL/ARTS improvements in addition to the power-flow operating region expansion consists primarily of the following changes:

1. The APRM flow-biased rod block and thermal power scram set points are increased to allow operation in the expanded region. This change includes hardware changes for clamping the trips in the high flow region to provide appropriate set points in the region from 75 to 105 percent flow.
2. The APRM flow biased scram set point is replaced by flow and power dependent limits on Maximum Average Planar Linear Generation Rate (MAPLHGR) and Minimum Critical Power Ratio (MCPR). Multipliers as a function of power and multipliers as a function of flow modify the operating MAPLHGR and MCPR are developed from the analysis of the core-wide operating occurrences described in the Browns Ferry Updated Final Safety Analysis Report (UFSAR). These become a part of the Browns Ferry Technical Specification (via the Core Operating Limit Report (COLR)). At any given power/flow state all four limits must be determined with the most limiting governing the operation.

To justify operation of the Browns Ferry units with ARTS/MELLL and to determine values for the limits previously described, GE has evaluated the UFSAR core-wide transients, considering the extremes within this MELLL scope. The evaluation determined the events most significantly impacted by MELLL, which are based on the Browns Ferry Unit 2 Cycle 8 at the current rated power of 3293 MWt. The following criteria were used to assure satisfying the applicable licensing requirements for the Browns Ferry Units:

1. MCPR safety limit shall not be violated as a result of any anticipated operational occurrence,
2. All fuel thermal-mechanical design bases shall remain within the licensing limits described in the generic fuel licensing report GESTAR-II, and
3. Peak cladding temperatures and maximum cladding oxidation fraction following a loss-of-coolant accident (LOCA) shall remain within the limits defined in Federal Regulation 10 CFR 50.46.

The operating limits associated with operation in the MELLL region are presented in Table 5-3 of topical report NEDC-32433P.



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In addition to the transient analysis, GE examined the effect of ARTS/MELLL on overpressure protection, thermal-hydraulic stability, LOCA, containment response, feedwater nozzle and sparger fatigue, flow induced loads and vibration, and standard relevant events in the accident category. These evaluations considered the areas examined and followed the methods used in previous staff-approved reviews of similar operation extensions. It was determined that with the limits used and derived for the ARTS/MELLL improvement, all required safety-associated limits within the above areas are met. For thermal-hydraulic stability, Browns Ferry Unit 3 is operating under the "Interim Recommendation for Stability Actions" of NRC Bulletin No. 87-07, Supplement 1. These operations are applicable to Browns Ferry Unit 3 operation with ARTS/MELLL, as is the case for other operating reactors with similar systems.

These evaluations and transient analyses have examined the same areas examined in previous ARTS/MELLL-related reviews by the staff. The method used in the evaluation have been approved previously by the staff, and the results and conclusion of the evaluation fall within expected ranges. There are no significantly new regions of operation or parameter values or limits compared to those previously reviewed and approved. This review has concluded that the safety evaluations contained in the GE report NEDC-32433P justify the proposed ARTS/MELLL improvements and operation within the power-flow and temperature boundaries and operating limits described in the report. As in previous reviews of similar ARTS/MELLL programs for other reactors the instrumentation changes, analyses, methods used, criteria and set points proposed are acceptable.

Changes to limits and operability requirements are necessary to support ARTS/MELLL operation. These include:

- a. Deletion of current set down requirements,
- b. New power and flow dependent MCPR and MAPLHGR limits,
- c. Changes to the APRM and RBM flow-biased scram, and
- d. New RBM limits and operability requirements.

A number of technical specification changes are required to implement these changes. However, most of the technical specification-related changes are proposed to be in the Browns Ferry COLR. The new values for the RBM and the changes to the MCPR and MAPLHGR limits, i.e., the new multipliers and limits, which are, or may be, cycle-specific are proposed to be in the COLR, which is designed for such parameters. The MCPR and MAPLHGR values already appear in the COLR. Directions for applying the multiplying factors and new limit curves are also provided in the COLR along with the corresponding limits. NEDC-32433P, which describes the changes and methodology, becomes a reference in the Technical Specifications Bases.

The review has indicated that the parameters proposed for the COLR are likely to be cycle-specific and are directly related to parameters already approved for the Browns Ferry COLR. It is appropriate that the instructions for using these parameters to provide the MCPR and MAPLHGR limits for a given reactor state point also be directly associated with the limits in the COLR. This review also has indicated that the material, organization of the material, and values in the COLR are reasonable and provide an acceptable change to the COLR. Thus, it is concluded that the placement of these values in the COLR is acceptable.



### 3.3 TECHNICAL SPECIFICATIONS

TVA has proposed changes to the Browns Ferry Unit 3 Technical Specifications to support the implementation of the NUMAC-PRNMS upgrade. These proposed changes are identical to the changes the staff previously approved to the Browns Ferry Unit 2 Operating License (Docket 50-260) with the issuance of Amendment No. 249 (September 11, 1997) and Amendment No. 253 (July 14, 1998). Amendment No. 249 approved the proposed changes in the CTS format and Amendment No. 253 approved the conversion from CTS to ISTS format. The staff has reviewed the proposed changes to the Browns Ferry Unit 3 Technical Specifications and has verified that they are identical to the approved Unit 2 changes associated with the implementation of the NUMAC-PRNMS upgrade. Therefore, the staff has determined that the proposed changes to the Unit 3 Technical Specifications are acceptable.

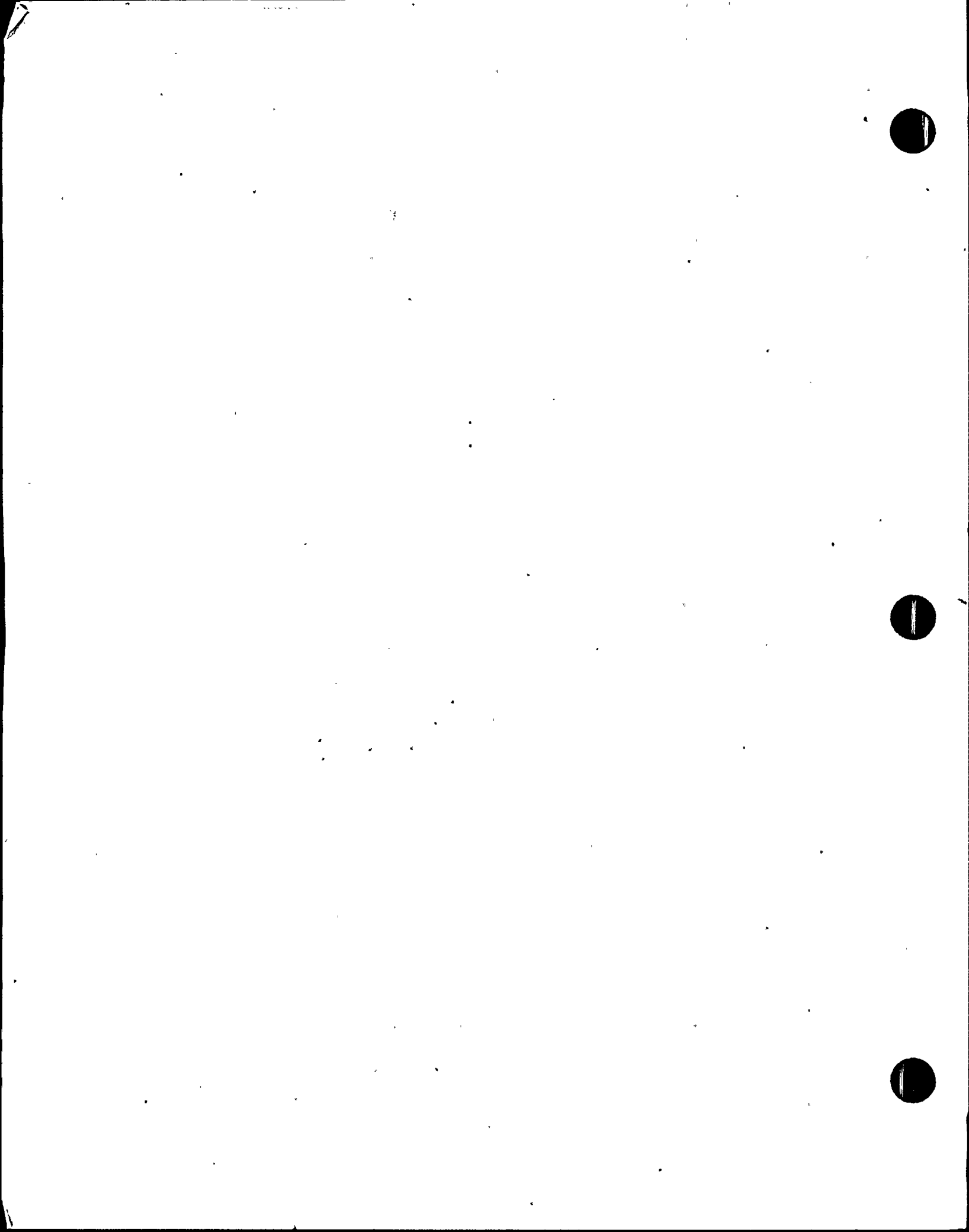
TVA has proposed MELLL and ICF changes to the allowed operating region for Browns Ferry Unit 3 and operating and physical modifications to change to ARTS operation. Technical specifications and COLR changes also are proposed to implement these changes. The staff has reviewed the information, including the GE reports submitted with these proposed changes. Based on this review, the staff concludes that appropriate material has been submitted to justify the changes, that the changes fall within the scope and bounds of past staff reviews in these areas, and that the changes to and values proposed for the Browns Ferry Unit 3 Technical Specifications (and COLR) are acceptable. The use of GE report NEDC-32433P in the Technical Specifications Bases and in the COLR as a reference to the ARTS/MELLL changes, methodology, and analyses approved here is also acceptable.

### 4.0 STATE CONSULTATION

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

### 5.0 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 and changes a surveillance requirement. 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 (60 FR 42609). 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.





6.0 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.

Principal Contributors: M. Waterman, R. Frahm, Sr., J. Williams, and A. De Agazio

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