TVA

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

CNL-13-135

December 20, 2013

10 CFR 50.90

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

Watts Bar Nuclear Plant, Units 1 and 2
Facility Operating License No. NPF-90
Facility Construction Permit No. CPPR-92
NRC Docket No. 50-390 and 50-391

Subject: **Application to Update Watts Bar Unit 1 License Condition 2.F to Allow Two-Unit Operation (WBN-TS-13-18)**

In accordance with the provisions of Title 10 of the Code of Federal Regulations (10 CFR) Part 50.90, "Application for amendment of license, construction permit, or early site permit," the Tennessee Valley Authority (TVA) is submitting a request for an amendment to Facility Operating License (OL) No. NPF-90 for Watts Bar Nuclear Plant (WBN), Unit 1.

This license amendment request revises Section 2.F (i.e., License Condition 2.F) of the OL for WBN, Unit 1. Section 2.F is the license condition associated with Fire Protection and defines the basis for NRC's approval of the Fire Protection Program that is applicable for the operation of WBN, Unit 1. TVA is currently in the process of completing the construction of WBN, Unit 2. Section 2.F is being updated to reflect two-unit operation and the Fire Protection Program that will be in effect after WBN, Unit 2, receives an operating license.

Enclosure 1 to this letter provides a description, technical evaluation, regulatory evaluation, and discussion of environmental considerations of the proposed changes. Attachment 1 of Enclosure 1 provides a mark-up of the proposed changes to License Condition 2.F. Attachment 2 to the enclosure provides the existing OL page retyped to show the proposed changes.

As stated previously, the proposed amendment revises License Condition 2.F to reflect two-unit operation and the Fire Protection Program that will be in effect after WBN, Unit 2, receives an operating license. The updated Fire Protection Program is documented in the two-unit Fire Protection Report (FPR) that will replace the current Unit 1 FPR. NRC's review of the as-designed version of the two-unit report is documented in Supplemental Safety Evaluation Report (SSER) 26 and NRC's ongoing review of the report will be documented in future SSERs (i.e., anticipated SSER 27). Due to this, only certain portions of the SSERs

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currently referenced in License Condition2.F (i.e., SSERs 18 and 19) will remain applicable to the operation of WBN, Unit 1 and Unit 2. To address this for both units, Enclosure 2 provides a draft FPR Part XI, "Supplemental Safety Evaluation Report Unit Applicability," that contains two tables and outlines the applicability of the SSERs. The first table, Table XI-1, "Section 9.5.1 of SSERs 18 and 26," addresses NRC's review of WBN's Fire Protection Program documented in Section 9.5.1, "Fire Protection," of SSERs 18 and 26. The second table, Table XI-2, "Appendix FF of SSERs 18, 19, 26 and 27," addresses NRC's review documented in Appendix FF of the SSERs. TVA plans to meet with the NRC staff in January 2014 to explain the SSER applicability tables and the supporting documentation for the tables. As part of this meeting, TVA will discuss with NRC the pending changes that need to be made to the as-designed two-unit report and establish a schedule for the submittal of the update which will include the new Part XI.

In Table XI-1 and XI-2, "F" indicates Full applicability, "P" indicates Partial applicability, "H" stands for Historical information, "N/A" designates the SSER sections that are no longer applicable to either unit and "N/I" designates an SSER section header number that contains no information. Unit applicability is denoted as follows:

a. F/18, F/19, F/26, F/27 - The entire content of the listed SSER section is applicable to the designated unit.
b. P/18, P/19, P/26, P/27 - Markups of the SSER specify the portion of the SSER section that remains applicable to a specific unit or both units and that portion that has been superseded, if any.
c. H/18, H/19 - The content of the listed SSER section contains historical background information only and does not contain direct NRC review information. These portions are retained for information only.
d. N/A - The content of the listed SSER section is not applicable to the designated unit.
e. N/I - Denotes an SSER section header number that contains no information.

Provided in Enclosures 3, 4 and 5 are annotated versions of Appendix FF of SSERs 18, 19 and 26, respectively. An annotated version of Section 9.5.1 for SSER 18 is provided in Enclosure 6 and Enclosure 7 contains an annotated version for SSER 26. The information provided in these enclosures is marked in the following manner:

a. Superseded text - ~~Strikethrough~~.
b. Fully applicable text - No marking
c. Partially applicable text - Vertical bar in right hand margin with applicable unit(s) noted.
d. Historical text - **<u>Bold and Underlined</u>**

TVA anticipates requesting an operating license for WBN, Unit 2, in January 2015. Based on this, TVA requests that this proposed amendment be approved by November 28, 2014. The implementation of the proposed license amendment should be effective the date the operating license is issued for WBN, Unit 2.

TVA has determined that there are no significant hazard considerations associated with the proposed change and that the change qualifies for a categorical exclusion from environmental review pursuant to the provisions of 10 CFR 51.22(C)(9)

The WBN Plant Operations Review Committee has reviewed this proposed change and determined that operation of WBN in accordance with the proposed change will not endanger the health and safety of the public.

Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter and the enclosures to the Tennessee Department of Environment and Conservation.

There is one regulatory commitment made in this submittal as listed in Enclosure 8. Please address any questions regarding this request to Mr. Gordon Arent at 423-365-2004.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 20th day of December 2013.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. Evaluation of Proposed Change
2. Draft Part XI, "Supplemental Safety Evaluation Report Unit Applicability"
3. Supplemental Safety Evaluation Report 18 Annotated
4. Supplemental Safety Evaluation Report 19 Annotated
5. Supplemental Safety Evaluation Report 26 Annotated
6. Section 9.5.1 of Supplemental Safety Evaluation Report 18 Annotated
7. Section 9.5.1 of Supplemental Safety Evaluation Report 26 Annotated
8. List of Regulatory Commitments

cc (Enclosures):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Watts Bar Nuclear Plant, Unit 1
Director, Division of Radiological Health - Tennessee State Department of Environment and Conservation

ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1

EVALUATION OF PROPOSED CHANGE

Subject: Application to Update Watts Bar Unit 1 License Condition 2.F to Allow Two-Unit Operation (WBN-TS-13-18)

1.0 SUMMARY DESCRIPTION

This evaluation supports a request to amend the Watts Bar Nuclear Plant (WBN), Unit 1, Facility Operating License (OL) Number NPF-90. The proposed change will revise Section 2.F (i.e., License Condition 2.F) of the WBN, Unit 1, OL. Section 2.F is the license condition associated with Fire Protection and defines the basis for the Nuclear Regulatory Commission's (NRC's) approval of the Fire Protection Program that is applicable for the operation of WBN, Unit 1. The Tennessee Valley Authority (TVA) is currently in the process of completing the construction of WBN, Unit 2. Section 2.F is being updated to reflect two-unit operation and the Fire Protection Program that will be in effect after WBN, Unit 2 receives an operating license.

TVA currently anticipates requesting an operating license for WBN, Unit 2, in January 2015. Based on this, TVA requests that the proposed amendment be approved by November 28, 2014. The implementation of the proposed amendment should be effective the date the operating license is issued for WBN, Unit 2.

2.0 DETAILED DESCRIPTION

2.1 Proposed Changes

Currently, WBN, Unit 1, License Condition 2.F states:

> "TVA shall implement and maintain in effect all provisions of the approved fire protection program as described in the Fire Protection Report for the facility, as approved in Supplement 18 (except page 80 of Appendix FF), revised page 80 of Appendix FF of Supplement 18 (as revised by Amendment No. 88 and Supplement 19 of the SER (NUREG-0847) subject to the following provision:
>
> TVA may make changes to the approved fire protection program without prior approval of the Commission, only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire."

NRC's review of the as-designed version of the two-unit Fire Protection Report (FPR) is currently documented in Appendix FF, "Fire Protection Program Safety Evaluation," of Supplemental Safety Evaluation Report (SSER) 26. Based on discussions with the staff, NRC's review of the as-constructed version of the two-unit FPR will be documented in Appendix FF of a future SSER. Considering this, the wording of the proposed change is an example and depending on the number of approved SSERs at the time WBN, Unit 2, is licensed that address Fire Protection, the wording of the license condition may include additional SSERs. The changes proposed below are consistent with the standard license condition defined in GL 86-10, "Implementation of Fire Protection Requirements" (Reference 1):

> "TVA shall implement and maintain in effect all provisions of the approved fire protection program as described in the Fire Protection Report for the ~~facility~~***operation of WBN Units 1 and 2***, as approved in Supplement***s*** 18, ~~(except page 80 of Appendix FF), revised page 80 of Appendix FF of Supplement 18 (as revised by Amendment No. 88 and Supplement~~ 19***, 26 and 27*** of the SER (NUREG-0847) subject to the following provision:

TVA may make changes to the approved fire protection program without prior approval of the Commission, only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

2.2 Need for Proposed Changes

In June 1982, the Nuclear Regulatory Commission staff (NRC staff) issued safety evaluation report (SER), NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2" (Reference 2) regarding TVA's application for licenses to operate WBN, Units 1 and 2. In SSERs 1 through 20, the NRC staff concluded that WBN, Unit 1, met all applicable regulations and regulatory guidance and on February 7, 1996, the NRC issued an OL to WBN, Unit 1 (Reference 3). The OL for WBN, Unit 1, included in Section 2.F a license condition that was based on Generic Letter 86-10. The license condition documented that NRC's approval of the Fire Protection Program for the operation of WBN, Unit 1 as being contained in SSER 18 and SSER 19. Appendix FF of SSERs 18 and 19 documented NRC's review of the FPR developed for single unit operation.

At the time WBN, Unit 1, received an OL, the completion of WBN, Unit 2, had been deferred. On March 4, 2009 (Reference 4), TVA submitted an updated application in support of a request for an OL for WBN, Unit 2. Since that time, construction activities for WBN, Unit 2, have continued and a two-unit FPR was developed to replace the FPR that is currently applicable to WBN, Unit 1.

As stated previously, the proposed amendment revises License Condition 2.F to reflect two-unit operation and the Fire Protection Program that will be in effect after WBN, Unit 2, receives an operating license. The updated Fire Protection Program is documented in the two-unit FPR that will replace the current Unit 1 FPR. NRC's review of the as-designed version of the two-unit report is documented in SSER 26 and NRC's ongoing review of the report will be documented in future SSERs. Due to this, only certain portions of the SSERs currently referenced in License Condition 2.F (i.e., SSERs 18 and 19) will remain applicable to the operation of WBN, Unit 1 and Unit 2. To address this for both units, Enclosure 2 provides a draft Part XI, "Supplemental Safety Evaluation Report Unit Applicability," that will be added to the two-unit FPR that outlines in two tables the applicability of the various SSERs. Additional material that supports Enclosure 2 and clarifies the applicability of the SSER sections is provided in Enclosures 3 through 7. TVA plans to meet with the NRC staff in January 2014 to explain the SSER applicability tables and the supporting documentation for the tables. As part of this meeting, TVA will discuss with NRC the pending changes that need to be made to the as-designed two-unit report and establish a schedule for the submittal of the update which will include the new Part XI.

2.3 Implementation

The TVA process governing the preparation and submittal of Technical Specification (TS) changes and License Amendment Requests requires that the appropriate organizations (e.g., Operations, Training, Engineering, Maintenance, Chemistry, Radiation Protection, and Work Control) identify the documents that are affected by each proposed change to the TSs and Operating Licenses. Among the items that are considered are training, plant modifications, procedures, special implementation constraints, design documents, surveillance instructions associated with TS Surveillance Requirements, Technical Requirements Manual, TS Bases, and Updated Final Safety

Analysis Report (UFSAR). The process requires that procedures and design document changes necessary to support TS Operability are approved prior to implementation of an NRC approved license amendment. The process also provides assurance that the remaining changes, if any, are scheduled and tracked for configuration control.

3.0 TECHNICAL EVALUATION

The principal systems included in WBN's Fire Protection System are listed below:

1. System 13, "Fire Detection System"
2. System 26, "High Pressure Fire Protection"
3. System 39, "CO2 Storage, Fire Protection, & Purging System"

For the licensing of WBN, Unit 1, System 39 and the majority of System 13 and System 26 were placed in service. Most of the physical attributes of the Systems 13, 26, and 39 were reviewed and approved by the NRC as documented in SSERs 18 and 19 (Reference 2). In addition to the portions of the systems available for Unit 1 operation, limited portions of Systems 13 and 26, primarily in the WBN Unit 2 Reactor Building, will be placed in service for WBN, Unit 2, operation. TVA submitted the as-designed two-unit FPR to the NRC on March 13, 2013 (Reference 5), describing the equipment required for two-unit operation. The NRC documented its assessment of the as-designed two-unit FPR in SSER 26 (Reference 2). TVA has committed to submit an as-constructed version of the two-unit report by October 15, 2014, prior to requesting an OL for WBN, Unit 2. The NRC will document its review of the as-constructed FPR in a future SSER and all applicable SSERs will be referenced in License Condition 2.F of the WBN, Unit 1, OL.

At the time WBN, Unit 2, receives an OL only certain portions of SSERs 18 and 19 will remain applicable to the operation of WBN, Unit 1. The NRC review of the two-unit FPR, documented in SSER 26 and any subsequent SSERs, updates or replaces some of the reviews documented in SSER 18 and SSER 19. As stated previously, a table that outlines the applicability of the SSERs for inclusion in SSER 27 is provided in Enclosure 2.

The technical aspects of the two-unit FPR are being evaluated by the NRC in SSER 26 and future SSERs for the licensing of WBN, Unit 2. Therefore, the changes proposed in this amendment request are administrative in nature and do not affect the design basis or operational controls related to the Fire Protection system. The approval of the proposed change will make the two-unit FPR applicable to WBN, Unit 1, through the references to the applicable SSERs in the license condition.

The proposed change is limited in scope and will align the OLs for WBN, Unit 1 and Unit 2, so that the Fire Protection Program may be managed by a common document (i.e., the two-unit FPR). Because this proposed change is administrative in nature, no accident analysis conclusions made in the WBN, Unit 1, UFSAR are affected. However, the WBN, Unit 1, FPR is incorporated by reference in Section 9.5.1, "Fire Protection System," of the WBN, Unit 1, UFSAR. This section of the UFSAR will be updated to reference the fire protection license condition in the WBN, Unit 1, and the WBN, Unit 2, OLs after WBN, Unit 2, receives an OL and the proposed changes are implemented. By doing this, the UFSAR will point to the fire protection licensing basis for two-unit operation (i.e., the two-unit FPR).

Based on the preceding and the NRC review of the two-unit FPR documented in SSER 26 and to be documented in a future SSER(s), WBN's Fire Protection Program is being structured for two-unit operation. This proposed change will update the operating license for WBN, Unit 1, to support two-unit operation in accordance with the two-unit FPR.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

General Design Criterion (GDC) 3, "Fire Protection," of Appendix A to 10 CFR 50 requires that structures, systems, and components important to safety be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. 10 CFR 50.48 requires that each operating nuclear power plant have a fire protection plan that satisfies GDC 3. It specifies what should be contained in such a plan and lists the basic fire protection guidelines for the plan. For WBN, Unit 1, the plan that satisfies these requirements is the FPR.

During the development of the WBN, Unit 1, FPR, TVA utilized the guidance provided in Generic Letter 88-12, "Removal of Fire Protection Requirements from Technical Specifications," (Reference 6) for the development of the Operating Requirements defined in Part II of the Unit 1 FPR. It should be noted that WBN, Unit 1, was not licensed to operate at the time the FPR was initially developed, therefore, the Operating Requirements were developed based on NUREG-0452, "Standard Technical Specifications for Westinghouse Pressurized Water Reactors" (Reference 7) and industry experience.

Generic Letter 88-12 also addresses the guidance provided in Generic Letter 86-10 and the adoption of the standard license condition specified in Enclosure 3 of Generic Letter 86-10. The license condition being revised by this proposed change (i.e., License Condition 2.F) is based on the standard license condition provided in Enclosure 3 of Generic Letter 86-10. Generic Letter 86-10 included a series of questions and answers. Question 8.4, "Future Changes," clarifies that changes to the fire protection license condition would require the submittal of a license amendment request (LAR) to NRC. This LAR satisfies that requirement.

Additional guidance regarding changes to the fire protection license condition is provided in the following discussion from Section 2.4.1, "Fire Protection Program Changes, Review and Approval," of SSER 18:

> "The applicant has elected to follow the guidance of GL 88-12 and incorporate the standard fire protection license condition. In addition to including, by reference, the NRC safety evaluation which approved the plant fire protection program, this license condition allows the applicant to make changes to the approved program without prior approval of the Commission if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.
>
> The applicant may change the approved fire protection program provided (1) the change or changes do not otherwise result in a change to the license condition or plant TSs result in an unreviewed safety question, and (2) the change or changes

do not result in failure to complete the fire protection program as approved by the Commission..."

In addition to the above, Part II of the WBN, Unit 1, FPR contains a set of references that includes the following regulatory documents:

1. Branch Technical Position (Auxiliary Power and Control Systems Branch) 9.5-1, Appendix A

2. 10 CFR 50 Appendix R - Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979

3. NRC letter dated August 29, 1977 - Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance

4. Generic Letter 81-12 - Fire Protection Rule and NRC Memorandum of Clarification for Generic Letter 81-12, dated March 22, 1982

5. Generic Letter 82-21 - Technical Specifications for Fire Protection Audits

6. Generic Letter 83-33 - NRC Positions on Certain Requirements of Appendix R to 10CFR50.

7. Generic Letter 86-10 - Supplement 1 - Fire Endurance Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains within the Same Fire Area

With the implementation of the proposed change, WBN, Unit 1, will continue to meet the applicable regulations and requirements listed above.

4.2 Precedent

TVA has identified no suitable precedent where the fire protection license condition for an operating unit was being updated to address the licensing of a second unit.

4.3 Significant Hazards Consideration

The proposed change will revise Section 2.F (i.e., License Condition 2.F) of the Watts Bar Nuclear Plant (WBN), Unit 1, Operating License (OL). Section 2.F is the license condition associated with fire protection and defines the basis for NRC's approval of the Fire Protection Program that is applicable for the operation of WBN, Unit 1. The Tennessee Valley Authority (TVA) is currently in the process of completing the construction of WBN, Unit 2. License Condition 2.F is being updated to reflect two-unit operation and the Fire Protection Program that will be in effect after WBN, Unit 2, receives an operating license.

TVA has evaluated whether or not a significant hazards consideration is involved with the proposed amendment(s) by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The overall effect of the licensing of WBN, Unit 2, on the safe operation of WBN, Unit 1, is being assessed by the reviews the NRC documents in Supplemental Safety Evaluation Reports (SSERs). This proposed change is limited in scope and will only align the operating licenses (OLs) for WBN, Unit 1 and Unit 2, so that the Fire Protection Program may be managed by a common document, the two-unit Fire Protection Report (FPR). Because this proposed change is administrative in nature, no accident analysis conclusions made in the WBN, Unit 1, UFSAR are affected. The proposed change does not revise or affect the Fire Hazards Analysis (FHA) or any component required for a fire safe shutdown.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The overall effect of the licensing of WBN, Unit 2, on the safe operation of WBN, Unit 1, is being assessed by the reviews the NRC documents in SSERs. This proposed change is limited in scope and does not revise or affect the FHA or any component required for a fire safe shutdown. In addition, no accident analysis conclusions made in the WBN, Unit 1, UFSAR are affected. Based on this, the proposed amendment will not alter the requirements or function for systems required during accident conditions.

Therefore, the proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No.

This proposed change is associated with the implementation of WBN's Fire Protection Program for two-unit operation as approved in NRC SSERs. Because the proposed amendment is administrative in nature (updates a condition of the WBN, Unit 1, OL), implementation of the amendment will not affect the manner in which safety limits or limiting safety system settings are determined nor will there be any effect on those plant systems necessary to assure the accomplishment of protection functions.

Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Based on the above, TVA concludes that the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92 (c), and, accordingly, a finding of "no significant hazards consideration" is justified.

4.4 Conclusions

In conclusion, based on the considerations discussed above, (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.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

1. NRC Generic Letter 86-10, "Implementation of Fire Protection Requirements," dated April 24, 1986.

2. NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2," June 1982, and the following supplements:

	Supplements		Supplements		Supplements
1	September 1982	10	October 1992	19	November 1995
2	January 1984	11	April 1993	20	February 1996
3	January 1985	12	October 1993	21	February 2009
4	March 1985	13	April 1994	22	February 2011
5	November 1990	14	December 1994	23	July 2011
6	April 1991	15	June 1995	24	September 2011
7	September 1991	16	September 1995	25	December 2011
8	January 1992	17	October 1995	26	June 2013
9	June 1992	18	October 1995		

3. NRC's Letter to TVA, "Issuance of Facility Operating License No. NPF-90, Watts Bar Nuclear Plant, Unit 1 (TAC M94025)," dated February 7, 1996, (ADAMS Accession Number ML080290360).

4. TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) Unit 2 - Operating License Application Update," dated March 4, 2009 (ADAMS Accession Number ML090700378)

5. TVA Letter to NRC, "Watts Bar Nuclear Plant (WBN) Unit 2 - Transmittal of Revised Unit 1/Unit 2 As-Designed Fire Protection Report (TAC NO. ME3091)," dated March 13, 2013 (ADAMS Accession Number ML13081A004).

6. NRC Generic Letter 88-12, "Removal of Fire Protection Requirements from Technical Specification," dated August 2, 1988.

7. NUREG 0542, "Standard Technical Specifications for Westinghouse Pressurized Water Reactors," Revision 4, dated Fall 1981.

Attachment 1

Proposed Operating License Changes (Mark-Ups) for WBN, Unit 1

(For the following mark-up, deletions are shown as strikethrough text and additions are shown as bold-italicized text.)

F. TVA shall implement and maintain in effect all provisions of the approved fire protection program as described in the Fire Protection Report for the ~~facility~~ ***operation of WBN Units 1 and 2***, as approved in Supplement***s*** 18, ~~(except page 80 of Appendix FF), revised page 80 of Appendix FF of Supplement 18 (as revised by Amendment No. 88 and Supplement~~ 19***, 26 and 27*** of the SER (NUREG-0847) subject to the following provision:

TVA may make changes to the approved fire protection program without prior approval of the Commission, only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

G. Deleted

H. The licensee shall have and maintain financial protection of such types and in such amounts as the Commission shall require in accordance with Section 170 of the Atomic Energy Act of 1954, as amended, to cover public liability claims.

Amendment ~~90~~

Attachment 2

Proposed Operating License Changes (Final Typed) for WBN, Unit 1

F. TVA shall implement and maintain in effect all provisions of the approved fire protection program as described in the Fire Protection Report for the operation of WBN Units 1 and 2, as approved in Supplements 18, 19, 26 and 27 of the SER (NUREG-0847) subject to the following provision:

TVA may make changes to the approved fire protection program without prior approval of the Commission, only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

G. Deleted

H. The licensee shall have and maintain financial protection of such types and in such amounts as the Commission shall require in accordance with Section 170 of the Atomic Energy Act of 1954, as amended, to cover public liability claims.

Amendment __

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

DRAFT
PART XI, "SUPPLEMENTAL SAFETY EVALUATION REPORT UNIT APPLICABILITY"

The initial Fire Protection Program for Watts Bar Nuclear Plant (WBN) was described in Section 9.5.1, "Fire Protection System," of the Final Safety Analysis Report (FSAR). NRC's review of WBN's initial Fire Protection Program was documented in Section 9.5.1 "Fire Protection," of NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant," dated June 1982. NRC acknowledged in the following statement from a letter dated March 5, 1992 (ML073550391), that the description of the Fire Protection Program in the FSAR (i.e., Section 9.5.1) was superseded by the single-unit FPR:

> "By this letter, we acknowledge that the February 5, 1992 report supersedes previous TVA fire protection commitments and submittals, as well as the present Fire Protection Program described in the Final Safety Analysis Report..."

WBN, Unit 1, was licensed based on NRC's review of the single-unit Fire Protection Report (FPR) documented in Supplemental Safety Evaluation Reports (SSERs) 18 and 19 (i.e., Section 9.5.1 and Appendix FF) and this was reflected in License Condition 2.F of the Operating License for Unit 1. As stated in the following excerpt from Section 9.5.1 of SSER 18, the review documented in the June 1982 Safety Evaluation Report (SER) has been superseded by the reviews NRC documented in SSER 18:

> "Section 9.5.1 of the FSAR, currently updated to Amendment 91, incorporates the fire protection program by reference. Likewise, the staff's detailed evaluation of the revised fire protection program is moved from the text of this section, and is relocated in Appendix FF of this SSER. Since the applicant's original fire protection program, as evaluated in the SER, has been fully superseded by subsequent submittals as stated above, the open issues (identified as Outstanding Issue 12, Confirmatory Issue 38, and Proposed License Condition 20) are considered resolved."

In addition to SSERs 18 and 19, NRC's has documented their review of the WBN's FPR developed for two-unit operation in SSER 26 with future reviews planned to be addressed in SSER 27. Part XI will be added to the WBN two-unit FPR as a means to establish those portions of SSERs 18, 19, 26 and 27 that are applicable for the licensing and operation of WBN, Unit 1, and Unit 2.

NRC's review of the WBN FPR (single-unit and two-unit) is documented in the SSERs in Section 9.5.1 and the associated Appendix FF, "Safety Evaluation - Watts Bar Nuclear Plant Fire Protection Program." The 1995 version of the FPR reviewed in SSERs 18 and 19 applied mainly to WBN, Unit 1, operation; however, some portions of SSERs 18 and 19 apply to the operation of both WBN, Unit 1 and Unit 2. Other portions of SSERs 18 and 19 are or will be, superseded by SSERs 26 and 27. Similarly, some portions of SSERs 26 and 27 will apply to both units while other portions apply only to WBN, Unit 2.

The proposed Part XI contains two tables; Tables XI-1, "Section 9.5.1 of SSERs 18 and 26," and Table XI-2, "Appendix FF of SSERs 18, 19, 26 and 27." Table XI-1 only addresses one section, Section 9.5.1, but since Table XI-2 addresses numerous sections, it was developed by identifying the sections in each SSER that discussed a common topic. Therefore, the table is not aligned by section number (i.e., Section No. column), but is aligned by topic based on the title of each SSER section (i.e., SSER Section Title column). Due to this, a section number and the description of the section may vary between the SSERs. An example of this is the section titled, "Fire Protection Technical Controls." For SSER 18, this section is Appendix FF, Section Number 2.4.3 and in SSER 26, it is Appendix FF, Section Number 2.4.4. Where this is the case, the applicable section numbers are listed in the "Section No." column. In addition, each topic is not discussed in all SSERs (i.e., 18, 19, 26 etc.). To clarify this, the SSERs that discuss the section(s) listed in "Section No." column, are listed in the column labeled "SSER." The "SSER Section Title" column contains the titles used in the SSERs. Note that some section numbers and titles are only a section heading and the section does not contain any NRC review material. The last two columns are designated as "Unit 1" and "Unit 2" and the applicability of the listed SSER section is designated in these columns.

The following is the draft Part XI submitted for NRC review.

1.0 Introduction

NRC's review of Watts Bar Nuclear Plant's (WBN's) initial Fire Protection Program was documented in Section 9.5.1 "Fire Protection," of NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant dated June 1982. The review documented in the 1982 Safety Evaluation Report (SER) has been superseded and/or supplemented by the reviews NRC has documented in Supplemental Safety Evaluation Reports (SSERs) 18, 19, 26 and 27. The 1995 version of the FPR reviewed in SSERs 18 and 19 applied mainly to WBN, Unit 1, operation; however, some portions of SSERs 18 and 19 apply to the operation of both WBN, Unit 1 and Unit 2. Other portions of SSERs 18 and 19 are superseded by SSERs 26 and 27. Similarly, some portions of SSERs 26 and 27 apply to both units while other portions apply only to WBN, Unit 2.

Part XI provides a historical road map of the previous NRC reviews of the FPR that can be used to determine if a Fire Protection Program change affects an NRC review. Part XI provides the following two tables to denote those portions of the SSERs that apply to WBN, Unit 1, versus WBN, Unit 2, versus both units:

- Table XI-1, "Section 9.5.1 of SSERs 18 and 26"
- Table XI-2, "Appendix FF of SSERs 18, 19, 26 and 27"

2.0 Discussion

WBN's updated Fire Protection Program is documented in the two-unit Fire Protection Report (FPR) that replaced the previous single unit FPR. NRC's review of the FPR is documented in SSERs 18, 19, 26 and 27. SSERs 18 and 19 were originally issued to address single unit operation and have been mostly superseded by SSERs 26 and 27 that addresses two-unit operation. However, SSERs 18 and 19 contain some information that remains applicable to only WBN, Unit 1, and some information that remains applicable to both units.

For each section in the SSERs (i.e., SSER Section 9.5.1 and Appendix FF), Table XI-1 and Table XI-2 outline the applicability of the sections to WBN, Unit 1, WBN, Unit 2, or both. The primary purpose of the tables is to establish what portions of SSERs 18, 19, 26 and 27 are applicable for the licensing and operation of WBN, Unit 1, and Unit 2. Table XI-1 only addresses one section, Section 9.5.1, but since Table XI-2 addresses numerous sections, it was developed by identifying the sections in each SSER that discussed a common topic. Therefore, the table is not aligned by section number (i.e., Section No. column), but is aligned by topic based on the title of each SSER section (i.e., SSER Section Title column). As noted in Table XI-2, the SSERs do not always use the same section number for a section title. Due to this, a section number and the description of the section may vary between the SSERs. An example of this is the section titled, "Fire Protection Technical Controls." For SSER 18, this section is Appendix FF, Section Number 2.4.3 and is Appendix FF, Section Number 2.4.4 in SSER 26. Where this is the case, the applicable section numbers are listed in the "Section No." column. In addition, each topic is not discussed in all four SSERs (i.e., 18, 19, 26 and 27). To clarify this, the SSERs that discuss the section(s) listed in "Section No." column, are listed in the column labeled "SSER." The "SSER Section Title" column contains the titles used in the SSERs. Note that some section numbers and titles are only a section heading and the section does not contain any NRC review material. The last two columns are designated as "Unit 1" and "Unit 2" and the applicability of the listed SSER section is designated in these columns. For these columns in the two tables, "F" indicates the section is full applicability to the stated unit, "P" indicates the section is partially applicability to the stated unit, "H" stands for historical information (i.e., information only) for the applicable unit, "N/A" designates the SSER sections that are not applicable to the unit and "N/I" denotes a section header number that contains no information.

A section can be partially applicable due to either of two situations. The first situation is the SSER 18 or 19 sections contain some information that remains applicable to one or both units but the remainder of the section has been superseded by a later SSER. The second situation is that the text in SSER 26 or 27 denotes that a portion of a section is applicable to only a specific unit. The partially applicable, historical, superseded or applicable sections are marked as discussed below.

A section that is marked as "N/A" represents either a section that has been totally superseded by a later SSER or the SSER states that the entire section is applicable to only one of the units.

The applicability of the SSERs is designated in Table XI-1 and Table XI-2 in the following manner:

a. F/18, F/19, F/26, F/27 - The entire content of the listed SSER section is applicable to the designated unit.
b. P/18, P/19, P/26, P/27 - Markups of the SSER specify the portion of the SSER section that remains applicable to a specific unit or both units and that portion that has been superseded, if any.
c. H/18, H/19 - The content of the listed SSER section contains historical background information only and does not contain direct NRC review information. These portions are retained for information only.
d. N/A - The content of the listed SSER section is not applicable to the designated unit.
e. N/I - Denotes an SSER section header number that contains no information.

To clarify the application of the designations defined above, TVA provided to the NRC a version of SSERs 18, 19 and 26 that was annotated in the following manner:

a. Superseded text - ~~Strikethrough.~~
b. Fully applicable text - No marking
c. Partially applicable text - Vertical bar in right hand margin with applicable unit(s) noted.
d. Historical text - **<u>Bold and Underlined</u>**

The annotated SSERs are available in WBN's Business Support Library in the "Fire Protection Report" folder.

Because the information contained in Part XI is a historical road map of previous NRC reviews, Part XI should not require updating unless NRC's review of WBN's Fire Protection Program is addressed in a future NRC Safety Evaluation or Supplemental Safety Evaluation Report.

Table XI-1 and Table XI-2
Watts Bar Nuclear Plant, Unit 1 and Unit 2 Fire Protection Program
Supplemental Safety Evaluation Reports (SSERs) 18, 19, 26, 27
Applicability of SSER Sections to Unit 1 or Unit 2

Table XI-1 - Section 9.5.1 of SSERs 18 and 26				
Source of SSER Section		SSER Section Title	Applicable SSER (Refer to Notes below)	
Section No. (same in all SSERs unless noted)	SSER		Unit 1	Unit 2
9.5.1	18, 26	Fire Protection	H/18, P/26	H/18,P/26

Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		SSER Section Title	Applicable SSER (Refer to Notes below)	
Section No. (same in all SSERs unless noted)	SSER		Unit 1	Unit 2
1.0	18, 26	INTRODUCTION	H/18,P/26	H/18, P/26
2.0	18, 26	FIRE PROTECTION PROGRAM	N/I	N/I
2.1	18, 26	Purpose and Scope	F/26	F/26
2.2	18, 26	Fire Protection Organization	F/26	F/26
2.3	18, 26	Fire Protection Quality Assurance Program	F/26	F/26
2.4	18, 26	Fire Protection Administrative and Technical Controls	N/I	N/I
2.4.1	18, 26	Fire Protection Program Changes, Review and Approval	F/26	F/26
2.4.2	18, 26	Fire Protection Administrative Controls	N/I	N/I
2.4.2.1	18, 26	Control of Combustibles	F/26	F/26
2.4.2.2	18, 26	Control of Ignition Sources	F/26	F/26
2.4.3	26	Compensatory Measures	F/26	F/26
2.4.3 (18) 2.4.4 (26)	18, 26	Fire Protection Technical Controls	P/18, F/26	P/18, F/26
2.5	18, 26	Fire Brigade and Fire Response	N/I	N/I
2.5.1	18, 26	Organization	F/26	F/26
2.5.2	18, 26	Training	F/26	F/26
2.5.3	18, 26	Equipment	F/26	F/26
2.5.4	18, 26	Fire Emergency Procedures and Pre-Fire Plans	F/26	F/26

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Watts Bar Nuclear Plant, Unit 1 and Unit 2 Fire Protection Program
Supplemental Safety Evaluation Reports (SSERs) 18, 19, 26, 27
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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
2.5.5	18	Emergency Response	F/18	F/18
3.0	18, 19, 26	GENERAL PLANT FIRE PROTECTION AND SAFE-SHUTDOWN FEATURES	N/I	N/I
3.1	18, 19, 26	Fire Protection Design	N/I	N/I
3.1.1	18, 19, 26	Building and Compartment, Fire Barriers	F/26	F/26
3.1.2 (26)	26	Fire Barriers Used To Separate Redundant Safe Shutdown Functions within the Same Fire Area	P/26	P/26
3.1.1 (18) 3.1.3 (26)	18, 26	Building and Compartment, Fire Barriers (18) Equipment Hatches and Stairwells (26)	F/26	F/26
3.1.2 (18) 3.1.4 (26)	18, 26	Fire Doors	F/26	F/26
3.1.3 (18) 3.1.5 (26)	18, 26	Fire Dampers	F/26	F/26
3.1.4 (18, 19) 3.1.6 (26)	18, 19, 26	Fire Barrier Penetrations Seals	N/I	N/I
3.1.4.1 (18, 19) 3.1.6.1 (26)	18, 19, 26	Electrical and Mechanical Penetrations Seals	H/18, F/19, F/26	H/18, F/19, F/26
3.1.4.2 (18) 3.1.4.1 (19) 3.1.6.2 (26)	18, 19, 26	Internal Conduit Fire Barrier Penetration Seals	F19, F/26	F19, F/26
3.2	18, 19, 26	Safe-Shutdown Capability	N/I	N/I
3.2.1	18, 19, 26	Separation of Safe-Shutdown Functions	F/26	F/26
3.2.2	18, 26	Safe Shutdown - General Plant Areas	F/26	F/26
3.2.3	18, 26	Safe-Shutdown Analysis	F/26	F/26
3.2.4	18, 26	Systems Required for Safe Shutdown	F/26	F/26
3.3	18, 26	Alternative Shutdown	N/I	N/I
3.3.1	18, 26	Areas in Which Alternative Shutdown Is Required	F/26	F/26
3.3.2	18, 26	Alternative Shutdown System	F/26	F/26
3.3.3	26	Alternative Shutdown Conclusion	F/26	F/26

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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
3.4	18, 26	Alternative Shutdown Performance Goals	F/26	F/26
3.4.1	18, 26	Reactivity Control	F/26	F/26
3.4.2	18, 26	Reactor Coolant Inventory	F/26	F/26
3.4.3	18, 26	Decay Heat Removal	F/26	F/26
3.4.4	18, 26	Process Monitoring	F/26	F/26
3.4.5	18, 26	Support Functions	F/26	F/26
3.4.6	26	Alternative Shutdown Performance Goals Conclusion	F/26	F/26
3.5	18, 26	Operator Manual Actions	P/18	F/26
3.5.1	26	OMAs for Safe Shutdown Success Path SSCs	P/26	P/26
3.5.1	18	Safe-Shutdown Procedure and Manpower	F/18	N/A
3.5.2	26	OMAs for SSCs That Are Important to Safe Shutdown	N/A	F/26
3.5.3	26	OMAs Required Prior to Control Room Evacuation	F/26	F/26
3.5.4	26	Safe Shutdown Procedures and Manpower	F/26	F/26
3.5.2 (18) 3.5.5 (26)	18, 26	Repairs	F/26	F/26
3.5.6	26	Unit 2 OMAs Involving Fire Area Re-Entry	N/A	F/26
3.6	18, 26	Associated Circuits	F/26	F/26
3.6.1	18, 26	Circuits Associated by Common Power Source	F/26	F/26
3.6.2	18, 26	Circuits Associated by Spurious Operation	F/26	F/26
3.6.3	18, 26	Circuits Associated by Common Enclosure	F/26	F/26
3.7	26	Current Transformer Secondaries	F/26	F/26
3.7	18	Fire Barriers Used To Separate Redundant Safe-Shutdown Functions Within the Same Fire Area	N/I	N/I
3.7.1	18	Raceway and Cable Tray Fire Barriers	F/18	F/18
3.7.2	18	Thermo-Lag 330-1 Fire Barrier Materials	F/18	F/18
3.7.3	18	Fire Tests Methods Used To Qualify the Watts Bar Fire Barriers	F/18	F/18
3.7.4	18	Acceptance Criteria for Fire Endurance Test	F/18	F/18

Table XI-1 and Table XI-2
Watts Bar Nuclear Plant, Unit 1 and Unit 2 Fire Protection Program
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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
3.7.5	18	Placement of Thermocouples in Test Assemblies	F/18	F/18
3.7.6	18	Test Specimen Design and Construction	F/18	F/18
3.7.6.1	18	Phase 1 - Conduit and Junction Box Program	F/18	F/18
3.7.6.2	18	Phase 2 - Cable Tray and Unique Configurations Test Program	F/18	F/18
3.7.6.3	18	Phase 3 - Cable Tray, Conduit, and Junction Box 3-Hour Fire Barrier Test Program	F/18	F/18
3.7.7	18	Fire Endurance Test Results	F/18	F/18
3.7.8	18	Conclusion - Electrical Raceway Fire Barrier Systems	F/18	F/18
3.7.9	18	Fire Barrier Deviations and Special Configurations	F/18	F/18
3.7.10	18	Ampacity, Derating Tests, and the Application of Test Results	F/18	F/18
3.7.11	18	Chemical Composition of Electrical Raceway Fire Barrier Materials	F/18	F/18
3.7.12	18	Seismic and Material Properties of Electrical Raceway Fire Barrier Systems	F/18	F/18
3.6.4 (18) 3.8 (26)	18, 26	High/Low-Pressure Interfaces	F/26	F/26
3.9	26	Assessment of Multiple Spurious Operations	P/26	P/26
3.8 (18, 19) 3.10 (26)	18, 19, 26	Smoke Control and Ventilation	F/26	F/26
3.9 (18) 3.11 (26)	18, 26	Lighting and Communications	F/26	F/26
4.0	18, 19, 26	FIRE PROTECTION SYSTEMS	N/I	N/I
4.1	18, 26	Water Supply and Distribution	F/26	F/26
4.2	18, 19, 26	Active Fire Control and Suppression Features	N/I	N/I
4.2.1	18, 19, 26	Automatic Fire Suppression Systems	N/I	N/I

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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section			**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**	**SSER Section Title**	**Unit 1**	**Unit 2**
4.2.1.1	18, 19, 26	Sprinklers and Fixed Spray Systems with Closed Heads	F/26	F/26
4.2.1.2	18, 26	Gas Suppression Systems	F/26	F/26
4.2.2	18, 26	Manual Suppression Capability	N/I	N/I
4.2.2.1	18, 26	Hose Stations	F/26	F/26
4.2.2.2	18, 26	Fire Extinguishers	F/26	F/26
4.3	18, 26	Fire Detection Capability	F/26	F/26
5.0	18, 19, 26	FIRE PROTECTION FOR SPECIFIC PLANT AREAS AND HAZARDS	N/I	N/I
5.1	18, 26	Containment	F/26	F/26
5.2	18, 19, 26	Control Room Complex	N/I	N/I
5.2.1	18, 19, 26	Control Room	F/19, F/26	F/19, F/26
5.2.2	18, 26	Auxiliary Control Room	F/26	F/26
5.3	18, 19, 26	Cable Spreading Room	F/26	F/26
5.4	18, 26	Switchqear Rooms	F/26	F/26
5.5	18, 26	Battery Rooms	F/26	F/26
5.6	18, 26	Turbine Lubrication and Control Oil Storage and Use Areas	F/26	F/26
5.7	18, 26	Diesel Generator Areas	F/26	F/26
5.8	18, 26	Diesel Generator Fuel Oil Storage Areas	F/26	F/26
5.9	18, 26	Safety-Related Pump Areas	N/I	N/I
5.9.1	18, 26	CCS Pump Area	F/26	F/26
5.9.2	18, 26	Charging Pumps	F/26	F/26
5.9.3	18, 26	AFW Pumps	F/26	F/26
5.9.4	18, 26	RHR Pumps	F/26	F/26
5.9.5	18, 26	ERCW Pumps	F/26	F/26
5.10	26	Other Plant Areas	N/I	N/I
5.10.1	26	Areas without Deviations or Evaluations	F/26	F/26

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Applicability of SSER Sections to Unit 1 or Unit 2

Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
5.10.2	26	Areas with Deviations or Evaluations	F/26	F/26
5.11	26	Specific Hazards	N/I	N/I
5.10.1 (18) 5.11.1 (26)	18, 26	Hydrogen Piping	F/26	F/26
5.10.2 (18) 5.11.2 (26)	18, 26	Askarel-Insulated Transformers (18) Transformers Installed Inside Buildings (26)	F/26	F/26
6.0	18, 19	DEVIATIONS FROM STAFF FIRE PROTECTION GUIDANCE	N/I	N/A
6.0	26	DEVIATIONS AND EVALUATIONS	F/26	F/26
6.1	26	Deviations and Evaluations Related to Criteria in Appendix R to 10 CFR Part 50 (Section Heading Only)	N/I	N/I
6.1 (18) 6.1.1 (26)	18, 26	Deviation – Required Instrumentation for Alternative Shutdown	F/26	F/26
6.2 (18) 6.1.2 (26)	18, 26	Deviation – Noncombustible Radiant Energy Heat Shields	F/26	N/A
6.3 (18) 6.1.3 (26)	18, 26	Deviation – Lack of Automatic Fire Suppression in Alternative Shutdown Locations	F/26	F/26
6.4 (18) 6.1.4 (26)	18, 26	Deviation – Intervening Combustibles	F/26	F/26
6.5 (18) 6.1.5 (26)	18, 26	Deviation – Partial Fire Wall between CCS Pumps	F/26	F/26
6.7 (18, 19) 6.1.6 (26)	18, 19, 26	Deviation – Emergency Lighting	F/26	F/26
6.8 (18) 6.1.7 (26)	18, 26	Evaluation – Lack of Total Area Suppression and Detection	F/26	F/26
5.1 (18) 6.1.8 (26)	18, 26	Evaluation – Reactor Coolant Pump Oil Collection System	F/26	F/26

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Watts Bar Nuclear Plant, Unit 1 and Unit 2 Fire Protection Program
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Applicability of SSER Sections to Unit 1 or Unit 2

Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
6.1.9	26	Evaluation -Unit 2 Manual Actions	N/A	F/26
6.1.10	26	Evaluation – Fire Hazards Analysis in Lieu of 10 CFR 50, Appendix R, Section III.G.2 Separation	F/26	F/26
6.1.10.1	26	Rooms without Credible Ignition Sources and Redundant Trains	F/26	F/26
6.1.10.2	26	Room 757.0-A13 – Refueling Floor and New Fuel Storage Vault	F/26	F/26
6.1.10.3	26	Room 757.0-A14 – Unit 2 Reactor Building Access Room and Room 757.0-A15 – Unit 2 Reactor Building Equipment Hatch	N/A	F/26
6.1.10.4	26	Unit 2 Containment Rooms	N/A	F/26
6.9 (18, 19) 6.2 (26)	18, 19, 26	Deviations - BTP 9.5-1, Appendix A (18, 19) Deviations and Evaluations Related to BTP (APSCB) 9.5-1, Appendix A Guidance (26)	N/I	N/I
6.9.1 (18) 6.2.1 (26)	18, 26	Deviation – Fire Detection in Refueling Room and New Fuel Storage Vault	F/26	F/26
6.9.2 (18) 6.2.2 (26)	18, 26	Deviation – Fire Doors	F/26	F/26
6.9.3 (18) 6.2.3 (26)	18, 26	Deviation – Openings in Fire Walls	F/26	F/26
6.9.4 (18) 6.2.4 (26)	18, 26	Deviation – Manual Hose Stations	F/26	F/26
6.9.5 (18) 6.2.5 (26)	18, 26	Deviation – Fire Barrier Penetration between Fuel Oil Transfer Pump Room and the Diesel Generator Building Corridor	F/26	F/26

Table XI-1 and Table XI-2
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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
6.2.6	26	Deviation – Undampered Penetrations between the Unit 1 Pipe Gallery and the Unit 1 Annulus and the Unit 2 Pipe Gallery and the Unit 2 Annulus	F/26	F/26
6.6 (18) 6.2.7 (26)	18, 26	Deviation – Openings in Fire Barriers	F/26	F/26
6.6 (18) 6.2.7.1 (26)	18, 26	Deviation – Openings in Fire Barriers (18) Ventilation and Purge Air Room Ventilation Penetrations (26)	F/26	F/26
6.2.7.2	26	Scuppers	N/I	N/I
6.6 (18) 6.2.7.2.1 (26)	18, 26	Deviation – Openings in Fire Barriers (18) ERCW Pump Room (26)	F/26	F/26
6.2.7.2.2	26	Yard Duct Bank	F/26	F/26
6.6 (18) 6.2.7.3 (26)	18, 26	Deviation – Openings in Fire Barriers (18) Auxiliary Building Penetrations (26)	F/26	F/26
6.2.7.4	26	Control Building Equipment Hatches to the Turbine Building	F/26	F/26
6.9.6 (18) 6.2.8 (26)	18, 26	Evaluation – Large Fire Dampers	F/26	F/26
6.2.9	26	Evaluation – Emergency Diesel Generators 7 Day Storage Tanks	F/26	F/26
6.2.10	26	Evaluation – Fire Dampers in the VCT Room Doors	F/26	F/26
6.2.11	26	Evaluation – Plexiglass Windows in the Security Control Point Building on the Refueling Floor	F/26	F/26
6.3	26	Additional Engineering Evaluations	N/I	N./I
6.3.1	26	Relaxation of FPR Surveillance Frequencies for the Reactor Buildings' Equipment Hatches	F/26	F/26
6.3.2	26	Relaxation of FPR Surveillance Requirements for Fire Dampers in High Radiation and Contaminated Areas	F/26	F/26

Table XI-1 and Table XI-2
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Table XI-2 - Appendix FF of SSERs 18, 19, 26 and 27				
Source of SSER Section		**SSER Section Title**	**Applicable SSER (Refer to Notes below)**	
Section No. (same in all SSERs unless noted)	**SSER**		**Unit 1**	**Unit 2**
6.3.2.1	26	Fire Damper 0-ISD-31-3846	F/26	F/26
6.3.2.2	26	Fire Dampers 0-ISD-31-3847 and 0-ISD-31-3848	F/26	F/26
6.3.3	26	Gap between Door and Frame for Fire Door W9	F/26	F/26
6.3.4	26	Relaxation of FPR Surveillance Requirements for Penetration Seals in High Radiation and Contaminated Areas	F/26	F/26
6.3.4.1	26	Spent Resin Tank Room (Room 692.0-A15)	F/26	F/26
6.3.4.2	26	Waste Hold Up Tank Room (Room 674.0-A1)	F/26	F/26
6.3.4.3	26	Hold Up Tank Rooms A and B (Rooms 676.0-A2 and 676.0-A3)	F/26	F/26
6.3.4.4	26	Gas Decay Tank Rooms (Rooms 692.0-A3 and 692.0-A5)	F/26	F/26
6.3.4.5	26	Barriers between High Radiation Area Rooms (Rooms 676.0-A2, 676.0-A3, 692.0-A3 and 692.0-A5)	F/26	F/26
6.3.5	26	Diesel Generator Building Lube Oil Storage Room Fire Doors	F/26	F/26
6.9.7	19	Fire Barrier Between Refueling Floor and Unit 2 Reactor Building	N/A	N/A
7.0	18, 26	CONCLUSION	P/18, P/26	P/26
8.0	26	CONFIRMATORY ITEMS	N/A	F/26

Table XI-1 and Table XI-2
Watts Bar Nuclear Plant, Unit 1 and Unit 2 Fire Protection Program
Supplemental Safety Evaluation Reports (SSERs) 18, 19, 26, 27
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Notes:

1. The table uses the following conventions.

   a. F/18, F/19, F/26, F/27 - The entire content of the listed SSER section is applicable to the designated unit.
   b. P/18, P/19, P/26, P/27 - Markups of the SSER specifies the portion of the SSER section that remains applicable to a specific unit or both units and that portion which has been superseded, if any.
   c. H/18, H/19 - The content of the listed SSER section contains historical background information only and does not contain direct NRC review information. These portions are retained for information only.
   d. N/A - The content of the listed SSER section is not applicable to the designated unit.
   e. N/I - Denotes an SSER section header number which contains no information.

2. The SSER sections are marked in the following manner:

   a. Superseded text - ~~Strikethrough.~~
   b. Fully applicable text - No marking
   c. Partially applicable text - Vertical bar in right hand margin with applicable unit(s) noted.
   d. Historical text - **<u>Bold and Underlined</u>**

ENCLOSURE 3

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

SUPPLEMENTAL SAFETY EVALUATION REPORT 18 ANNOTATED

(Note that the layout of the text on the following pages
of this enclosure depicts the text as it is in the SSER)

APPENDIX FF
SAFETY EVALUATION
WATTS BAR NUCLEAR PLANT FIRE PROTECTION PROGRAM
DOCKET NOS. 50-390/391
(TAC M63648)

1.0 INTRODUCTION

In the SER, the staff discussed its review of the Watts Bar fire protection program and fire hazards analysis submitted by the applicant on April 18, 1977; September 8, 1980; and August 28, 1981. Subsequently, the applicant submitted the revised Watts Bar Fire Protection Report (FPR) by letters dated September 15, 1993, and its revisions dated November 18, 1994; April 27, 1995; May 31, 1995; June 15, 1995; and September 28, 1995.

The applicant initially revised its report on the fire protection program for Watts Bar as a result of a comprehensive review under its Fire Protection Corrective Action Program (see Section 1.13.1 of SSER 18). The principal program changes in Revision 0 are the removal of fire protection from the Technical Specifications (TSs) and documentation of the fire area reanalysis. The applicant undertook this reanalysis to take advantage of the compartmentation at Watts Bar and further subdivide the fire areas, and had described this reanalysis in the previous February 5, 1992, revision of the Fire Protection Report. By letter dated June 2, 1993, the applicant described the revised fire areas. The applicant has incorporated this description into this revision of the FPR. This revision also reflects fire protection programmatic improvements and incorporates changes made in response to NRC comments. In this revision, the applicant states that its fire protection program has been developed to comply with, and is based on, the requirements of General Design Criterion 3 in Appendix A to 10 CFR Part 50, 10 CFR 50.48, paragraphs (a) and (e), and the applicant's commitment to Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50, and Appendix A to Auxiliary Power Conversion Systems Branch (APCSB) Branch Technical Position (BTP) 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to July 1, 1976." In addition, the applicant committed to conform to the following NRC fire protection guidance: (1) NRC letter dated June 20, 1977, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance"; (2) Generic Letter (GL) 81-12, "Fire Protection Rule," and NRC memorandum of clarification to GL 81-12, dated March 22, 1982 (publicly available memorandum, R. Mattson to D. Eisenhut); (3) Generic Letter 82-21, "Technical Specifications for Fire Protection Audits"; (4) GL 83-33, "NRC Positions on Certain Requirements of Appendix R to 10 CFR 50"; (5) GL 86-10, "Implementation of Fire Protection Requirements"; and (7) GL 88-12, "Removal of Fire Protection Requirements from Technical Specifications."

The applicant has identified its revised Fire Protection Report as the document that describes the operational phase of the fire protection program and consolidates the regulatory fire protection program into a single document. Accordingly, the staff has rereviewed the entire fire protection program, evaluating it against the NRC fire protection requirements and review guidance listed above. Because Watts Bar has two units of identical design (except as noted), this evaluation applies to the fire protection program for both units.

By letters of July 9, 1994; November 11, 1994; December 23, 1994; and March 29, 1995, the applicant submitted the results of its qualification testing of 1-hour Thermo-Lag 330-1 and 3-hour Thermo-Lag 770-1 electrical raceway fire barrier systems (ERFBSs). The staff has reviewed the applicant's fire endurance testing program, its acceptance criteria, and the test results against the fire barrier acceptance criteria guidance provided in GL 86-10, "Implementation of Fire Protection Requirements," and its supplement, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used To Separate Redundant Safe Shutdown Trains Within the Same Fire Area."

As a result of this review, the staff, in letters of December 2, 1992; April 6, 1994; December 14, 1994 (meeting summary by P. S. Tam, dated December 21, 1994); April 19, 1995; and May 10, 1995, requested additional information related to the adequacy of the proposed fire protection program. The applicant, in letters of February 10, 1993; November 26, 1993; July 1, 1994; January 27, 1995; and May 26, 1995, submitted the requested information to the staff for review and committed to make certain modifications to plant fire protection features and to the plant fire protection program modifications and its implementation.

In addition, the staff met with the applicant on October 13, 1993 (summary by P. S. Tam, dated November 5, 1993), April 27, 1995 (summary by P. S. Tam, dated May 9, 1995), May 30, 1995 (site review notification by P. S. Tam, dated May 19, 1995), August 15, 1995 (summary by M. Bugg, dated August 30, 1995), and October 10, 1995 (summary by M. Bugg, dated October 13, 1995) to discuss technical issues related to Watts Bar's fire protection program and its implementation.

The staff's consultant, Brookhaven National Laboratory, participated in reviewing associated circuits and post-fire safe shutdown capability and in preparing this safety evaluation, and concurs with the staff's findings.

~~2.0 FIRE PROTECTION PROGRAM~~

~~2.1 Purpose and Scope~~

~~In its fire protection plan, the applicant has consolidated previous program commitments into a single document. This document is referenced by the Watts Bar Final Safety Analysis Report (FSAR) and will be updated in conjunction with the updates to the FSAR. The fire protection plan describes (1) the organization supporting the Watts Bar fire protection program, (2) plant fire protection features, (3) the plant's fire prevention program, (4) the plant's emergency response organization, (5) plant operating requirements for fire protection features and systems, and (6) the testing and inspection requirements for these plant fire protection features. This plan establishes the basis for Watts Bar's compliance with Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50 and the guidelines of Appendix A to BTP (APCSB) 9.5-1.~~

~~The fire protection plan summarizes the results of the fire hazards analysis (FHA) performed for all the fire areas and zones established at Watts Bar. The plan summarizes the FHA for each fire area by describing the physical~~

~~characteristics of the fire area, combustible loadings and anticipated fire severity, and fire suppression and detection capability available in each plant area. The plan also describes how post-fire safe shutdown would be ensured if a serious fire occurred in the fire area.~~

~~In this plan, the applicant described the measures that are established at Watts Bar to implement a defense-in-depth fire protection program in plant areas important to plant safety. These measures consist of (1) preventing fires from starting, (2) detecting fires rapidly, controlling them, and promptly extinguishing them, and (3) protecting systems important to safety so that a fire that is not promptly extinguished will not prevent the plant from achieving and maintaining safe shutdown conditions.~~

~~2.2 Fire Protection Organization~~

~~The applicant's fire protection organization consists of a corporate management oversight and an onsite plant implementation organization. The Senior Vice President for Nuclear Operations has the overall responsibility for establishing the corporate programs and policies related to nuclear power fire protection. This authority is delegated to the General Manager, Operational Services. The General Manager is responsible for developing and assessing fire protection programs at the applicant's nuclear power plants. Agreements are maintained between TVA Nuclear and TVA Fossil and Hydro Power organizations for ensuring that the applicant's nuclear power plant fire brigades are properly trained and that their knowledge and skills are sufficient to handle onsite fire emergencies.~~

~~The onsite fire protection organization is responsible for developing, implementing, and administering the Watts Bar fire protection program. The ultimate authority for this program rests with the Site Vice President. However, this authority has been delegated to the Plant Manager. The Plant Manager is responsible for management oversight of the development and implementation of the operational phase of the Wats Bar fire protection program. Under the Plant Manager, the Operations Manager is responsible for developing, implementing, and controlling the onsite program. This authority is delegated to the onsite Fire Protection Manager, who has the overall responsibility for the implementation and maintenance of the onsite fire protection program.~~

~~With respect to plant modifications which impact plant fire protection features, the Site Vice President delegates the responsibility for fire protection-related design activities at Watts Bar to the Engineering Manager. The Engineering Manager is responsible for maintaining Watts Bar's post-fire safe-shutdown capability and plant fire protection features in conformance with Appendix A to BTP (APCSB) 9.5-1 and Appendix R to 10 CFR Part 50.~~

~~The staff finds that the applicant's proposed fire protection organization did not take any exceptions to Position A.1 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.3 Fire Protection Quality Assurance Program~~

~~Following the fire protection quality assurance (QA) program guidance established by Appendix A to BTP (APCSB) 9.5-1 and the NRC letter dated June 20, 1977, on "Nuclear Plant Fire Protection Functional Responsibilities,~~

~~Administrative Controls, and Quality Assurance," the applicant has developed a QA program for fire protection features that protects post-fire safe-shutdown capability and safety-related structures, systems, and components. The applicant's fire protection QA program uses the applicable parts of the Tennessee Valley Authority Nuclear Quality Assurance Plan (TVA-NQA-PLN-89-A). The applicant has committed to implement a program which performs independent audits and inspections of its Watts Bar fire protection program. The applicant stated that its program is in accordance with GL 82-21, "Technical Specifications for Fire Protection Audits." The applicant's Nuclear Assurance organization is responsible for conducting the fire protection-related audits. The applicant has committed to perform the following fire protection program audits:~~

~~(1) an annual fire protection and loss prevention inspection and audit~~

~~(2) a biennial audit of the fire protection program and its implementing procedures~~

~~(3) a triennial fire protection and loss prevention inspection and audit~~

~~Consistent with the guidance in GL 88-12, "Removal of Fire Protection Requirements From Technical Specifications," the applicant will include these audits and their frequencies in the Administrative Controls section of the plant TSs.~~

~~The staff concludes that the applicant's proposed fire protection QA program did not take any exceptions to Position C of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.4 Fire Protection Administrative and Technical Controls~~

~~2.4.1 Fire Protection Program Changes, Review and Approval~~

~~The applicant has elected to follow the guidance of GL 88-12 and incorporate the standard fire protection license condition. In addition to including, by reference, the NRC safety evaluation which approved the plant fire protection program, this license condition allows the applicant to make changes to the approved program without prior approval of the Commission if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.~~

~~The applicant may change the approved fire protection program provided (1) the change or changes do not otherwise result in a change to the license condition or plant TSs result in an unreviewed safety question, and (2) the change or changes do not result in failure to complete the fire protection program as approved by the Commission. These changes to the fire protection program will be performed under the provisions of 10 CFR 50.59. In this context, the determination of whether an unreviewed safety question as defined in 10 CFR 50.59(a)(2) is involved would be based on the postulated fire in the FHA for the fire area affected by the change. The applicant has committed to maintain, in an auditable form, a current record of all such changes, including analysis of the effects of the change on the fire protection program, and to make all such records available to NRC inspectors upon request.~~

~~In addition, changes to the Watts Bar Fire Protection Report and the administrative fire protection program procedures as specified by Watts Bar TSs will be reviewed by the Plant Operations Review Committee (PORC). The Nuclear Safety Review Board (NSRB) provides independent oversight of fire protection audits and technical reviews as specified by the Watts Bar TSs. The applicant has committed, in its fire protection plan, to include the fire protection program responsibilities of these review groups in Section 6.0, "Administrative Controls," of the Watts Bar TSs.~~

~~2.4.2 Fire Protection Administrative Control~~

~~2.4.2.1 Control of Combustible~~

~~The applicant has established a program to control combustibles. The Watts Bar program objectives are to (1) provide instruction and guidelines during general employee training on the application and use of combustible materials at Watts Bar, (2) control the application and use of chemicals, (3) perform periodic plant housekeeping inspections and have housekeeping tours by management and the onsite fire protection organization, (4) control in situ combustibles through the design/modification review and installation process, and (5) control transient combustibles through the implementation of administrative controls.~~

~~The applicant has established Administrative Procedure FPI-0100, "Control of Transient Fire Loads." Implementation of this procedure will establish administrative controls for the handling of combustible materials such as fire-retardant wood, paper, plastic, and flammable and combustible gases and liquids. In addition, the applicant's combustible control program has established combustible control zones in the plant. The applicant considers these zones to be subdivisions of fire areas and to serve as a form of a fire barrier, providing fire separation of redundant fire safe-shutdown equipment. Transient combustibles may not be stored in these zones unless an adequate fire protection engineering evaluation or compensatory measures, or both, are implemented.~~

~~The staff concludes that the applicant's proposed program to control combustibles did not take any exceptions to Position B.3.c of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.4.2.2 Control of Ignition Sources~~

~~The applicant has established a program for controlling ignition sources such as welding, cutting, grinding, and the use of open flame. The applicant's program in Administrative Procedure FPI-0101, "Control of Ignition Sources," specifies that a member of Watts Bar line supervision reviews and approves the issuance of "hot work" permits based on plant conditions and a prior inspection of the proposed work area. The ignition source on a hot-work permit is valid for only one job. The applicant's program will establish a trained fire watch for all ignition source work activities that are performed in safety-related and safe-shutdown areas of the plant. These fire watches, in addition to performing their duties during the hot-work activities, will remain in the area for a minimum of 30 minutes after the work has been completed to ensure that potential residual ignition conditions do not exist.~~

~~The staff concludes that the applicant's proposed program to control ignition sources did not take any exceptions to Positions B.3.a and b of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

2.4.3 Fire Protection Technical Controls

~~GL 88-12 provides guidance for removing fire protection from the plant TSs. This guidance specifies that the limiting conditions for operation (LCOs) and surveillance requirements associated with fire detection systems, fire suppression systems, fire barriers, and administrative controls that address fire brigade staffing can be removed from the plant TSs and incorporated into the final safety analysis report (FSAR) (Watts Bar fire protection plan as referenced by the Watts Bar FSAR). In addition, GL 88-12 refers to GL 81-12, "Fire Protection Rule," which asks licensees to provide TSs for equipment used for safe-shutdown capability not currently covered by existing TSs. In its fire protection plan, the applicant has confirmed that the plant equipment used to achieve and maintain post-fire safe shutdown from either inside or outside the main control room is included in the plant TSs and the Fire Protection Report.~~

~~As to the safe-shutdown fire equipment not included in the TSs, the applicant made note of it in Watts Bar Fire Protection Report Table 14.10. The applicant has established testing and inspection requirements which assist in evaluating the operability of the non-TS-related safe-shutdown fire equipment and instrumentation. In FPR Section 14.0, "Fire Protection Systems and Features Operating Requirements," the applicant established the limiting conditions for plant operation with this equipment or instrumentation inoperable. With one or more of the required items of equipment listed in Watts Bar Fire Protection Report Table 14.10 inoperable, restore the equipment to the operable status within 30 days, or then either place the equipment in the condition required for fire safe shutdown, provide a backup means of instrumentation monitoring, or be in Mode 3 within 6 hours and Mode 4 within the following 12 hours.~~

~~In addition, the Watts Bar Fire Protection Report establishes testing and inspection requirements for the following fire protection features: (1) fire detection instrumentation, (2) water supply, (3) water-based fire suppression systems, (4) carbon dioxide (CO_2) systems, (5) fire hose stations and associated preaction control valves, (6) fire hydrants, (7) fire-rated assemblies, and (8) emergency battery lighting units.~~

~~In a letter dated April 6, 1994, the staff requested additional information regarding the proposed testing and inspections requirements for certain plant fire protection features and the associated compensatory measures used in the event a fire protection feature becomes inoperable. On July 1, 1994, the applicant submitted this additional information.~~

With respect to fire detection instrumentation, the staff had concerns with how the applicant classified fire detection devices as either Function A (early warning) or as Function B (fire suppression system initiation). In the event that a Function A fire detection device becomes inoperable, an hourly roving fire watch as defined by the Watts Bar Fire Protection Report is required to be established. Function B fire detection devices, in addition to their fire suppression system initiation function, perform an early-warning function, and the inoperability of these devices impacts both the early- U1 U2 warning function and the fire suppression system initiation function. For those cases in which an automatic fire suppression system protecting safe-shutdown functions within the same fire area is inoperable or the early warning function of the Function B detection devices in this area are operable, the applicant's fire protection operating requirements (Watts Bar Fire Protection Report Sections 14.3.1 and 14.4.1) requires a continuous fire watch to be established. For those cases in which the automatic fire suppression system and the Function B detection devices are protecting plant areas that would not expose redundant safe-shutdown functions to thermal or smoke damage from a single fire, the applicant's fire protection operating requirements (Sections 14.3.2 and 14.4.2) would require an hourly fire watch to be established. The staff finds this acceptable.

The applicant's fire protection operating requirements for inoperable fire detection devices inside containment prescribe a roving fire watch to enter the containment every 8 hours or to monitor the air temperature in the containment once an hour. The staff was concerned that this fire protection operating requirement to monitor the containment air temperature did not establish a temperature limit or a rise criterion which would be considered an indication of a fire. The applicant, in its July 1, 1994 submittal, indicated that the temperature criteria established by Watts Bar TS 3.6.5, "Containment Air Temperature," would be used. In the event the containment air temperature exceeded the established limits, the LCO from this TS would be followed. The staff finds this acceptable.

The applicant has established operating requirements for the fire protection water supply. These operating requirements establish how many fire pumps are required to be operable U1 to adequately ensure that water fire suppression capability is functional to all areas on the U2 site. The minimum of three fire pumps (each pump with a capacity 1590 gallons per minute and 300 feet of head) and an operable flow path with suction from the forebay, through distribution piping, sectionalizing, control or isolation valves, supplied from two directions, leading to yard hydrants, hose stations and to each water-based fire suppression system. In its operating requirements, the applicant, stated that, if the required fire protection water supply or pumping capability, or both, became inoperable, alternative methods of establishing backup fire pump and water supply capabilities would be implemented. The staff requested information concerning these alternative measures. The applicant submitted this information on July 1, 1994. The applicant stated that, if one of the required fire pumps became inoperable, an alternative pump with flow and pressure characteristics equal to or exceeding those of the inoperable pump would be connected to the system. In addition, the applicant committed to ensuring that the water supply to the backup fire pump will come from a reliable source and the driver for the backup pump will be capable of operating upon a loss of offsite power. The staff finds the applicant's criterion for establishing alternative fire water pumping capability acceptable.

The staff found that the applicant's operating requirement for fire barriers did not address raceway or equipment fire barrier systems. The staff asked the applicant to clarify this operating requirement. The applicant stated in its July 1, 1994, submittal, that it would revise the bases for this operating requirement to make it clear that raceway fire barrier systems are covered by the fire barrier operating requirement. The staff finds this acceptable.

Throughout the "bases" sections for testing and inspection requirements, the applicant specified test frequencies that were based on industry operating experience. The staff asked the applicant to further justify the test frequencies that it specified in its testing and inspection requirements. The applicant, in its July 1, 1994, response, stated that the types of tests and the inspections and their frequencies were based on the test and inspection guidance provided by the Standard Technical Specifications (STSs) and fire protection industry consensus standards (i.e., National Fire Protection Association Standard No. 72E (NFPA-72E), NFPA-25, and NFPA-101). The staff has reviewed these testing and inspection requirements and finds them all acceptable except for item 14.2.E, "testing of fire pumps." As an alternative to the NFPA-20 fire pump performance testing guidance, the applicant proposed to evaluate the electric fire pumps by testing them on an 18-month cycle at the rated head (130 psig/300 foot-head) and at two diverse points, one above and below the rated head. For the diesel fire pump, the applicant proposed to evaluate its performance by testing it every 18 months at three points on the fire pump curve. These points are (1) 140 percent of rated pressure at shutoff capacity (175 psig/404 foot-head), (2) 100 percent of capacity (2500 gpm) at rated pressure (125 psig/288 foot-head), and (3) 150 percent of capacity (3750 gpm) at 65 percent of rated pressure (81 psig/187 foot-head). The staff finds the applicant's proposed fire pump performance test acceptance criteria acceptable, and finds that (for the electric fire pumps) it conforms to the intent of general industry fire protection engineering practice (refer to NFPA-20).

In Revision 3 to the Fire Protection Report, the applicant revised its inspection frequency for fire protection valves, fire hose stations, and valve and flow tests to determine valve blockage in hose station valves. The testing and requirements for testable fire protection valves associated with the water-based fire suppression systems (item 14.3.a) specified a 92-day frequency in lieu of the original 31-day frequency. The applicant based this change in frequency on a water-based fire protection valve surveillance test on a study it performed for its Sequoyah facility. This study evaluated the fire protection valve lineups for a 2.5-year period and, based on the data, the applicant determined that there would be 99.96-percent probability for the 31-day test frequency that the valves would be in their proper alignment, and a 99.90-percent probability of proper valve alignment if a 92-day test frequency was implemented. On the basis of this evaluation, the staff finds acceptable the applicant's change in surveillance frequency for testable fire protection valves associated with the water-based fire suppression system.

U1
U2

With respect to the testing and inspection requirement to visually inspect hose stations, the applicant revised it test frequency from 31 days to 92 days. The basis for changing the frequency is that there have been infrequent problems found with hose stations at the applicant's other nuclear power plants. The staff finds acceptable the applicant's change in this visual inspection surveillance frequency.

In its review of compensatory measures the staff noted that the applicant proposes to use roving and continuous fire watches and alternative compensatory measures. The staff had concerns regarding how the applicant is applying these measures. The applicant's definition of a continuous fire watch allows the fire watch to patrol multiple fire areas and zones as long as the area in which the fire protection impairment is located is patrolled every 15 minutes. The applicant's basis for this definition, as stated in a July 1, 1994 submittal, is that this continuous fire watch criterion is similar to that which was approved for its Sequoyah facility. The staff found that this response was not accurate and the continuous fire watch definition for Watts Bar is not consistent with the continuous fire watch definition established by Sequoyah's bases. The applicant, in Revisions 2 and 3 to its Fire Protection Report, provided additional clarification regarding its definition of continuous fire watch and its technical basis. The applicant proposes that a trained continuous fire watch be in the fire area at all times, that the fire area contain no impediment to restrict the movements of the watch, and that each compartment within the fire area is patrolled at least once every 15 minutes with a margin of 5 minutes. The applicant, however, has identified specific cases in which it takes exception to this definition. In Section 13.0 of the Watts Bar Fire Protection Report, the applicant specified the continuous fire watch routes which cross more than one fire area boundary and that it classifies as exceptions to a continuous fire watch staying within one fire area. These routes are (1) diesel generator building, 742 ft 0 in.; (2) diesel generator building, 760 ft 0 in.; (3) auxiliary building rooms 757.0-A2, 757.0-A9, 757.0-A10, 757.0-A11, 757.0-A12, 757.0-A21, 782.0-A1 and 782.0-A2 when sprinkler valves 0-FCV-26-143 and 0-FCV-26-322 are out of service; (4) auxiliary building rooms 772.0-A1, 772.0-A6, 772.0-A7, 772.0-A8, 772.0-A9, 772.0-A12, and 772.0-A16 when sprinkler valves 0-FCV-26-143 and 0-FCV-26-322 are out of service; (5) auxiliary building rooms 757.0-A5, 757.0-A14, 757.0-A15, 757.0-A16, 757.0-A17, 757.0-A24, 782.0-A3, and 782.0-A4 when sprinkler valves 0-FCV-26-151 and 0-FCV-26-326 are out of service; (6) auxiliary building rooms 772.0-A2, 772.0-54, 772.0-A10, 772.0-A11, and 727.0-A15 when sprinkler valves 0-FCV-26-151 and 0-FCV-26-326 are out of service; and (7) auxiliary building 737 ft 0 in. elevation when the automatic suppression or detection system, or both, is out of service. In the event that the automatic suppression or detection systems, or both, in the above areas cannot be restored within the time specified by Watts Bar Fire Protection Report Section 14.0, "Fire Protection Systems and Features Operating Requirements," then an augmented compensatory measure will be taken. This measure would limit these 15-minute fire watch patrols from patrolling multiple fire areas and would restrict their patrol to the boundaries of a single fire area. The staff finds acceptable this application of a continuous fire watch.

U1
U2

In addition, the applicant identified other alternative compensatory measures such as the use of additional or alternative fire protection equipment, temporary/portable detection systems, and closed-circuit television (CCTV). In considering an alternative compensatory measure for an inoperable fire protection feature, the applicant committed to perform an evaluation that demonstrates technical equivalency to the standard compensatory measure identified in the STSs. The applicant proposes to use temporary/portable fire detection systems in lieu of a continuous fire watch. The applicant's basis for using portable detection systems is that the staff has approved them for other facilities (Diablo Canyon, Davis-Besse). When the need occurs to use this system, the temporary detectors will be attached as closely as possible to the ceiling of the area and in the general location of the detector which is out of service. The area with the impaired fire detection system as well as the associated temporary/portable fire detection system monitor units will be observed by an hourly roving fire watch. The staff finds the use of a temporary fire detection system which is capable of automatically transmitting its identification of a potential fire condition to the main control room linked with a roving hourly fire watch which patrols the area of concern as an acceptable alternative to a continuous fire watch

The applicant proposes to use CCTV as an alternative compensatory measure when special circumstances, such as personal safety, operational conditions, or the ALARA standard preclude the use of a fire watch in the area. The staff finds this use of CCTV acceptable, provided that the applicant performs an evaluation that documents why a fire watch can not be instituted and demonstrates that the use of CCTV will provide a technical equivalency to the specified compensatory measure. U1 U2

~~The staff concludes that the applicant's proposed surveillance and test program for plant fire protection features did not take any exceptions to Position B.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.5 Fire Brigade and Response~~

~~2.5.1 Organization~~

~~A fire brigade of at least five members will be maintained on site at all times. The fire brigade will comprise a fire brigade leader or fire protection shift supervisor and four fire brigade members. The brigade will not include the shift operations supervisor and the other members of the operations shift crew needed to perform a safe shutdown of Watts Bar. The fire brigade will not include any other individuals required for other essential plant functions that may be necessary during a fire emergency. The fire brigade leader for each fire brigade shift will be supported by the incident commander or assistant shift supervisor. This individual will have sufficient training and knowledge of plant operations and safety-related systems to understand the effects of fire and fire suppressants on safe-shutdown capability.~~

~~Before initial training and annually thereafter, the applicant's fire brigade program requires each fire brigade member to undergo a medical review and to receive medical approval to perform strenuous fire fighting-related physical activities and wear special respiratory equipment.~~

~~In order to accommodate conditions for unexpected absence, the fire brigade composition can be less than the minimum required for a period of time not to exceed 2 hours. The staff finds that the applicant's proposal for fire brigade staffing and organization did not take any exceptions to Position B.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.5.2 Training~~

~~The applicant's fire brigade training program consists of initial (classroom and practical) training and recurrent training, which includes periodic instruction, fire drills, and annual fire brigade training.~~

~~The initial training program consists of but is not limited to (1) instruction and practical exercises in fire extinguishment and the use of fire-fighting equipment; (2) identification of fire hazards and types of fires that could occur in the plant; (3) identification of the location of fire-fighting equipment in each fire area of the plant; (4) instruction on the proper use of plant fire-fighting equipment; (5) instruction on the proper use of communications, lighting, ventilation, and emergency breathing apparatus; (6) instruction on the toxic characteristics of the products of combustion; and (7) instruction and practical exercises in fighting fires inside buildings and .~~

~~tunnels. In addition to initial training, the fire brigade is instructed on fire-fighting procedures and procedure changes, the plant fire-fighting plan with emphasis on each individual's responsibility, and the latest plant modifications and changes affecting the fire-fighting plans.~~

~~The recurrent training consists of regular planned meetings held every 3 months. These meetings will repeat the initial training subjects over a 2- year period. Each member of the fire brigade is required to attend this training in order to remain qualified. Fire brigade drills will be preplanned by the applicant to establish the objectives and conducted by the fire brigade training instructor or the instructor's designee. Onsite fire brigade drills will be conducted as follows: (1) a minimum of one drill per fire brigade shift will be conducted every 92 days, (2) a minimum of one unannounced drill will be conducted per fire brigade shift per year, and (3) at least one drill per fire brigade shift will be conducted on the backshift. Every fire brigade member will be required to attend at least two drills per year.~~

~~The applicant will hold annual training for each fire brigade member. This training will provide instruction, under actual fire-fighting conditions, on the proper methods for fighting various types of fires similar in magnitude, complexity, and difficulty to those that could be encountered in the plant. This training will include actual fire extinguishment and the use of fire- fighting equipment under strenuous conditions.~~

~~In addition to the annual fire brigade training, the applicant will hold annual briefings for the local fire departments to ensure their continued understanding of their role in the event of a fire emergency on site. The applicant will also hold an annual drill for the fire department and the fire brigade. This drill will include a fire emergency scenario of sufficient complexity to judge how effectively the offsite fire department and the plant fire brigade work together and how well the fire department handles the emergency. The offsite fire department briefings and drills will be held for those departments that have active aid agreements with the plant.~~

~~The staff concludes that the applicant's proposed fire brigade training program did not take any exceptions to Positions B.5.b and c of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~2.5.3 Equipment~~

~~The applicant has stated that fire-fighting equipment is provided throughout the plant and is strategically placed to coincide with the fire hazards present or anticipated. The applicant claims that delays in the fire brigade obtaining fire-fighting equipment is minimized because of the distribution and availability of this equipment throughout the plant. The equipment available to the fire brigade includes (1) motorized fire-fighting apparatus, (2) portable ventilation equipment, (3) fire extinguishers, (4) self-contained breathing apparatus, (5) fire hose, nozzles, and fittings, (6) foam equipment, (7) personal protective equipment, (8) communications equipment, (9) portable lighting, and (10) ladders specifically dedicated for fire fighting.~~

~~From the applicant's description of the onsite fire-fighting equipment available to the fire brigade, the staff finds that the brigade is adequately equipped to handle onsite fire emergencies.~~

~~2.5.4 Fire Emergency Procedures and Pre-Fire Plans~~

~~The applicant's fire emergency procedures and pre-fire plans specify actions taken by the individual discovering a fire and actions considered by the emergency response organization (e.g., control room operators and the plant fire brigade). These procedures provide different levels of response based on whether there is an actual fire/smoke condition or an fire detection system annunciation (e.g., a single fire detection system zone annunciation in a cross-zoned area will not carry the same level of response as a cross-zone annunciation in the same area). For example, a report of a fire by plant personnel and cross-zone annunciation of the fire detection system would get an automatic response of the plant fire brigade to the pending fire emergency. The applicant has implemented fire emergency procedures and pre-fire plans which specify the actions to be taken by the individual discovering the fire and actions to be considered by the emergency response organization. The applicant has developed pre-fire plans to support the fire-fighting activities in plant areas important to safety. Specifically, these plans are developed for safety-related areas, safe-shutdown areas, and areas that present a hazard to safety-related equipment or plant shutdown. The pre-fire plans provide the following information to the fire brigade: (1) equipment in the fire area, (2) access and egress routes to the fire area, (3) any unique fire-fighting methods required because of the hazards in the area, (4) locations of fire protection features and equipment, (5) special fire, toxic, and radiological hazards in the area, and (6) special precautions.~~

~~The staff concludes that the applicant's proposed fire brigade preplans and fire emergency procedures did not take any exceptions to the NRC letter dated June 20, 1977, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance," and, therefore, are acceptable.~~

2.5.5 Emergency Response

The applicant intends to uses its fire brigade to respond to the following onsite/owner-controlled area emergencies: (1) fires, (2) medical emergencies, (3) hazardous material spills, and (4) rescues. The staff finds acceptable the applicant's utilization of the plant fire brigade.

~~3.0 GENERAL PLANT FIRE PROTECTION AND SAFE-SHUTDOWN FEATURES~~

~~3.1 Fire Protection Design~~

~~3.1.1 Building and Compartment, Fire Barriers~~

~~Three-hour fire-rated barriers are provided between the reactor building and auxiliary building, control building and auxiliary building, service building and auxiliary building, and control building and turbine building. All floors, walls, and ceiling enclosing the control room and the cable spreading room are rated at a minimum of 3 hours. Three-hour fire separation will be maintained between adjacent diesel generator units within the diesel generator building. The main control room area contains peripheral rooms which are located within the main control room complex. These peripheral rooms have automatic sprinklers, detectors, and 1-1/2-hour fire-rated barriers separating them from the main control room.~~

~~The applicant has applied the following criteria for subdividing the plant into fire areas and zones: (1) fire areas are bounded by 3-hour fire barriers and (2) fire areas or rooms within fire areas are separated into fire zones by fire barriers that have either 1-, 2-, or 3-hour fire ratings. If the separation between the zones is less than 3 hours, then automatic suppression and detection systems are provided or deviations are justified (refer to SER Section 6.0, "Deviations From Staff Fire Protection Guidance").~~

~~In general, fire barriers in buildings or compartments (walls, ceilings, floors) are constructed either of reinforced concrete or of reinforced-concrete blocks. The concrete fire barriers are at least 12 inches thick and the concrete block barriers are normally 8 inches thick. The applicant's analysis of these fire barrier designs concludes that these barriers are similar to Underwriters Laboratories, Inc. (UL) listed concrete block barrier designs (Design Nos. U905, U905, U906, and U907) which are 2-hour to 4-hour fire rated. In addition, the applicant's analysis used the guidance of Section 6, Chapter 5, of the Fire Protection Handbook (Seventeenth Edition). This section correlates fire rating and thickness of reinforced concrete. On this basis, the applicant concludes that the 12-inch-thick reinforced-concrete barrier exceeds the 3-hour rating assigned to these Watts Bar barriers.~~

~~At Watts Bar, equipment hatches in the floor or fire barriers in the ceiling can be categorized as~~

~~(1) precast concrete plugs~~
~~(2) steel covers with overlapping mating surfaces~~
~~(3) open hatches and stairwells~~

~~Precast concrete plugs are associated with radiation shielding and, as fire barriers, are equivalent to the floor or ceiling fire barrier in which they are located.~~

~~The steel covers have either a water curtain around them or redundant safe-shutdown trains on either side which are separated from each other by a cumulative horizontal distance of at least 20 feet. Both sides are provided with automatic fire detection and suppression systems.~~

~~The open hatches and stairwells are either separated by horizontally redundant shutdown trains that are at least 20 feet apart, or one train has been protected by a 1-hour fire barrier (without the fire barrier if a water curtain has been installed around the opening). In either case, automatic fire detection and suppression systems are located on both sides of the openings. The only exception to these arrangements is in the refueling area.~~

~~In general, the safe-shutdown systems at Watts Bar are isolated from exposure to fire hazards by physical isolation, spatial separation, automatic suppression, or some combination of these. Redundant safety-related functions are separated from each other or protected as specified by applicable NRC guidelines to preclude damage by a single fire hazard.~~

~~The staff concludes that the applicant's proposed technical basis for sub-dividing the plant into fire areas and zones offers an equivalent level of fire safety to that of Position D.1 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~3.1.2 Fire Doors~~

~~The applicant proposes to use fire door assemblies (doors, frames, and hardware) that are UL listed in door openings in required fire barriers. These door assemblies will be either A-labeled (3 hour) or B-labeled (1-1/2 hour). A-labeled doors will be used in 3-hour fire barriers, and B-labeled doors will be installed in fire barriers having a fire rating of 2 hours or less.~~

~~Sliding fire doors are provided in selected locations. These sliding fire doors are closed by a fusible link or~~ $\cancel{CO_2}$ ~~system pressure, or both.~~

~~The staff finds that the applicant's design criteria and bases related to the installation of rated fire doors in fire barrier assemblies is in accordance with the guidelines of Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~Some doors cannot be purchased as labeled fire doors (e.g., air lock doors, equipment doors, submarine-type doors). The applicant has evaluated these doors and concludes that these doors will prevent fire from spreading through the fire barrier (refer to Section 6.0, "Deviations From Staff Fire Protection Guidelines").~~

~~3.1.3 Fire Dampers~~

~~To prevent the propagation of fire through the duct, the applicant has provided fire dampers in HVAC ducts that penetrate required fire barriers. In areas protected by automatic~~ $\cancel{CO_2}$ ~~suppression systems, these dampers also close during the~~ $\cancel{CO_2}$ ~~system discharge. The fire dampers are actuated by a fusible link rated at 165 °F (74 °C). Some fire dampers are also closed by electrothermal links that are electrically activated by a signal from the fire detection system.~~

~~The applicant has implemented a procedure to shut down the air handlers in the event of a fire in fire areas that have fire dampers which may not close under certain HVAC air flow conditions. The air handlers will be shut down upon receipt of multiple alarms from fire detector zones or the actuation of a deluge valve from the fire suppression system and the dispatch of the plant fire brigade. Because of this procedure, the staff has reasonable assurance that the fire dampers will function properly during a fire. At the same time, the staff has reasonable assurance that air handlers will not be shut down unnecessarily because of unwanted fire alarms.~~

~~The staff concludes that the fire dampers, except for fire dampers 1-ISD-31-3807 and 2-ISD-31-3882 (refer to Section 6.9.6, "Large Fire Dampers"), are installed in accordance with the applicant's commitment and the guidelines of Section D.1.j of Appendix A to BTP (APCSB) 9.5-1.~~

3.1.4 Fire Barrier Penetration Seals

3.1.4.1 Electrical and Mechanical Penetration Seals

~~In FPR Sections II.12.6, VIII.D.1.j, and D.3.d, the applicant committed to install fire barrier mechanical and electrical penetration seals that were qualified by tests meeting the guidance and acceptance criteria of American~~

~~Society for Testing and Materials (ASTM) Standard E-814-1994, "Standard Test Method for Fire Tests of Through-Penetration Fire Stops" (for mechanical fire barrier penetration seals) and Institute of Electrical and Electronics Engineers (IEEE) Standard 634-1978, "IEEE Standard Cable Penetration Fire Stop Qualification Test" (for electrical fire barrier penetration seals).~~

IEEE-634 states that the qualification fire endurance test program for electrical penetration seals should include tests of penetration seal designs representative of the in-plant configuration. This standard

(1) gives guidance on bounding cable fill conditions

(2) gives guidance on the size of the penetration openings

(3) requires that the test specimen have a cable fill representative of its end use and the plant-specific cable construction (e.g., if end use was a tray filled with cross-linked polyethylene instrument cables, the test specimen should be representative of this condition)

(4) gives guidance on the temperature conditions on the unexposed surface of the test specimen

(5) recommends that at least three thermocouples be located on the surface of the penetration seal to measure the temperature on the material's face

(6) states that temperatures shall be measured at the cable jacket, cable penetration fire stop interface, and the interface between the fire stop and through metallic components

Using this basic guidance, the staff, during a July 1995 site visit, reviewed the applicant's engineering analysis and qualification tests for the following typical Watts Bar electrical penetration seal designs:

- **cable tray seal detail L1 (3-hour design)**
- **cable tray seal detail H1 (3-hour design)**
- **conduit seal (internal) A2-2 (3-hour design)**
- **cable tray seal detail B1 (3-hour design)**
- **multiple cable tray penetration seal detail G2 (2-hour design)**
- **cable tray seal detail A4 (3-hour design)**
- **cable tray seal detail A4A (3-hour design)**
- **cable tray detail M4 (3-hour design)**

ASTM Standard E-814 states that the test specimens for the mechanical penetration seals shall be representative of actual field installations. The standard

(1) gives guidance on determining the temperature conditions on the unexposed surface of the test specimen

(2) recommends that at least three thermocouples be located on the surface (under insulated thermocouple pads) of the penetration seal to measure the temperature on the material's face

(3) states that temperatures shall be measured at the interface between the fire stop and through-penetrating metallic component

Using this basic guidance, the staff, during a July 1995 site visit, reviewed the applicant's engineering analysis and qualification tests for the following typical Watts Bar mechanical penetration seal designs:

- pipe seal detail V (3-hour design)
- multiple pipe seal detail X (3-hour design)
- pipe sleeve seal detail XXXVII (3-hour design)
- pipe seal detail XLIV (3-hour design)
- pipe seal detail XLVII (3-hour design)
- pipe boot seal detail L (3-hour detail)
- pipe boot/silicone foam seal detail LXXXIII (3-hour detail)
- pipe boot/silicone foam seal detail LXXXIV (3-hour detail)

The applicant has not completed its engineering analysis and evaluation of fire barrier penetration seals. On the basis of a preliminary review of portions of this draft engineering report assessing the penetration seal program (Report No. 0006-00922-02A, Revision 0A), the staff specifically identified concerns regarding qualification testing and extrapolation of thermal performance data for cable slots, large cable tray blockouts, and large- diameter mechanical sleeves. In addition, the staff determined that (1) the tests did not meet the commitments described in the applicant's FPR; (2) the test specimens in the qualification test reports are either not representative of or bound the as-built penetration seal conditions; (3) the acceptability of the bounding conditions for the critical fire penetration seal material and design attributes (e.g., material density, location/need for damming boards, amount and type of cables penetrating the seal test specimens) were not clear; (4) the installation details and their qualification basis did not clearly establish the fire endurance rating of the seal design; (5) testing of similar test specimens did not yield consistent thermal performance results; (6) the qualification testing referenced by the draft engineering report generally deviated significantly from the testing (collection of thermal performance data) guidance provided in industry fire endurance penetration seal testing standards; and (7) the applicant had not properly evaluated the auto-ignition temperatures (refer to IEEE-634 for guidance) of the various types of cable jacket and insulation used and pass-through fire-rated penetration seals.

~~Therefore, the staff concludes from its audit of the applicant's penetration seal program that the fire endurance test specimens identified by the applicant's engineering analysis to qualify typical cable tray slots, large cable tray blockouts, and large-diameter mechanical sleeves penetration seal do not adequately demonstrate the fire resistive rating of these typical penetration seal designs and, therefore, they do not conform to the guidelines of Positions D.1.j and D.3.d of Appendix A to BTP (APCSB) 9.5-1 and are not acceptable. The staff will track resolution of this issue by TAC M63648.~~

~~3.1.4.2 Internal Conduit Fire Barrier Penetration Seals~~

~~Conduits will be provided with internal smoke and gas seals. These seals shall have a minimum of a 3-inch-deep silicone foam and 1-inch ceramic fiber damming installed at the bottom or back side of the foam seal. The applicant will install these internal conduit seals at the first available opening in the conduit. Conduits that terminate in closed junction boxes or other noncombustible sealed enclosures do not need internal smoke seals, except for conduits in the auxiliary and secondary containment envelope boundary. An~~

~~electrical cubicle, such as in a motor control center and in a switchgear cabinet, is considered combustible. Conduits that are routed through the fire area and that do not terminate in the area do not require internal seals.~~

~~Conduits that terminate within 1 foot of a fire barrier are required to have an internal fire seal. Conduits that are less than 3/4 inch in diameter and that terminate 1 foot or more (but not more than 3 feet) away from the fire barrier are not required to have internal fire seals. Conduits that are 1 inch in diameter and less than 2 inches in diameter, are required to have smoke seals. Conduits that are 2 inches in diameter and that terminate 3 feet or more and less than 5 feet from the fire barrier and that have a cable fill greater than 40 percent are not required to have internal fire or smoke seals. If the cable fill is less than 40 percent, a smoke seal is required. Conduits that are more than 2 inches in diameter and that terminate 1 foot or more, but not more than 3 feet, away from the fire barrier are required to have internal fire seals. Conduits that are more than 2 inches in diameter and 4 inches or less in diameter, with a cable fill that exceeds 40 percent, are not required to be sealed. Conduits that are 2 inches or less in diameter and that terminate more than 5 feet and less than 22 feet away from the fire barrier are not required to have internal fire seals. Conduits that are greater than 2 inches in diameter and that terminate at more than 5 feet and less than 22 feet from the fire barrier are required to have an internal smoke seal, except that conduits that are greater than 2 inches and 4 inches or less in diameter and that have a cable fill greater than 40 percent are not required to have internal smoke seals. Conduits that terminate more than 22 feet away from the fire barrier are not required to have internal seals.~~

~~The staff finds that the applicant's proposal to install internal conduit fire and smoke seals is equivalent to the guidelines of Positions D.1.j and D.3.d of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~3.2 Safe-Shutdown Capability~~

~~3.2.1 Separation of Safe-Shutdown Functions~~

~~In order to ensure that one train of equipment remains free of fire damage where components of redundant trains of systems necessary to achieve and maintain hot-standby conditions are located within the same fire area outside the containment, the applicant has committed to separate equipment, components, cables, and associated circuits of redundant, safe-shutdown systems by the following means:~~

~~(1) a fire barrier that has a 3-hour fire rating~~

~~(2) a horizontal distance of more than 20 feet free of intervening combustibles or other fire hazards, and by installing automatic fire detection and suppression systems in that free space (If intervening combustibles or otheer fire hazards are present, then the fire area is required to be protected by automatic sprinkler systems that comply with the applicants expanded sprinkler coverage criteria (See Section 6.0, "Deviations From Staff Fire Protection Guidance.").)~~

~~(3) a fire barrier that has a 1-hour fire rating with automatic fire detection and suppression systems installed in the area~~

~~For safe-shutdown components located inside the containment building, the applicant will use one of the means noted above, or one of the following means to achieve separation between trains:~~

~~(1) automatic fire detection and suppression installed in the area~~

~~(2) separation of equipment, components, and associated circuits of redundant systems by a radiant energy shield (refer to Section 6.0, "Deviation - Noncombustibile Radiant Energy Heat Shields")~~

~~In order to conform to the fire protection and safe-shutdown train separation criteria specified by items 1, 2, and 3 above, the applicant took credit for a safe-shutdown analysis volume evaluation methodology.~~

~~The analysis volume methodology is used by the applicant in order to sub-divide a large fire area and subject it to a detailed Appendix R safe-shutdown analysis and ensure that one train of safe-shutdown capability is free of direct fire damage. An analysis volume (AV) can consist of an entire fire area or a portion of a larger fire area. When the AV is a portion of the fire area, it can consist of multiple rooms, a single room, portions of a room (normally defined by column line locations), or any combination of the above. Each AV that involves only a portion of a room includes a 20 foot wide (minimum) "buffer zone" between it and the adjacent AV. The buffer zones are analyzed as part of the larger AV and as a separate AV.~~

~~In performing safe-shutdown analyses, safe-shutdown components and cables are assigned to the AV containing the component. Additionally, components located in the buffer zones are assigned to an AV for the buffer zone.~~

~~The applicant's safe-shutdown analysis is performed assuming that all components and cables in the AV are damaged by the postulated fire. A set of safe-shutdown equipment is then selected and corrective actions designated to ensure safe-shutdown functions can be maintained with the selected equipment. In order to provide reasonable assurance that Watts Bar satisfied the technical requirements of Appendix R, Section II.G, "Fire Protection of Safe-shutdown capability," the applicant identified and used the following types of analysis volumes:~~

- ~~*Fire Area* - The fire area is separated from other adjacent areas by rated barriers (walls, floors, and ceilings) that are sufficient to withstand the hazards associated with the area and, as necessary, to protect equipment in the area from a fire outside the area. The fire area may be a single room or several individual rooms. If redundant safe-shutdown cables are located in the AV, they are protected by an electrical raceway fire barrier system throughout the AV (i.e., from rated fire barrier to rated fire barrier). For example, this AV would be bounded on all sides by 3-hour fire-rated barriers. The fire barriers provide for protection of safe-shutdown components within this AV in accordance with Appendix R, Section III.G (i.e., 3-hour electrical raceway fire barrier system protecting one safe-shutdown train from 3-hour fire-rated area boundary fire barrier to 3-hour fire-rated area boundary fire barrier with the fire area).~~

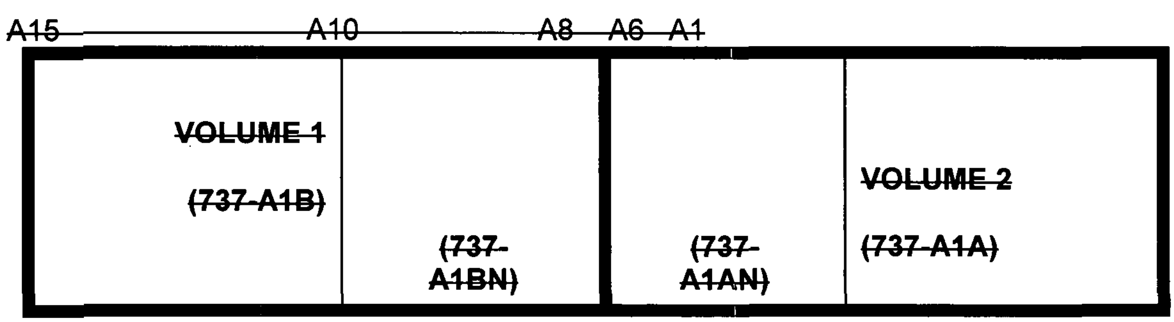
- ~~*Single Room Within a Fire Area* - The room is separated from other adjacent rooms in a fire area by regulatory fire barriers (walls, floors,~~

~~and ceilings) that have a 1-hour or greater fire rating. The fire barriers are in accordance with Appendix R, Section III.G.2.a or c. If redundant safe-shutdown cables are located in the AV (i.e., single room within a fire area), they are protected by an electrical raceway fire barrier system throughout the AV (i.e., from regulatory fire barrier to regulatory fire barrier).~~

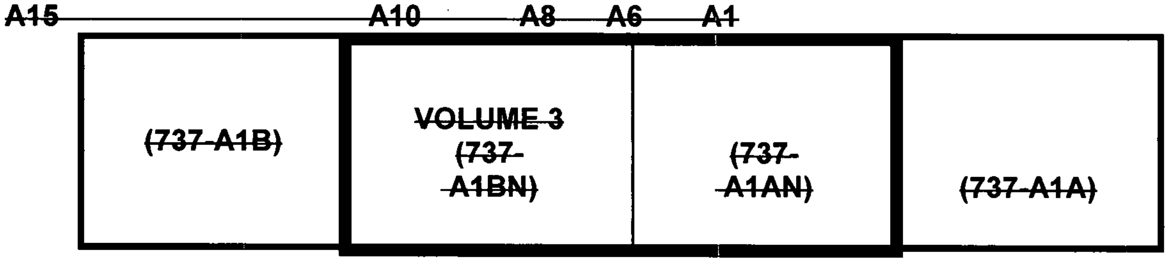
- ~~*Combination of Rooms Within a Fire Area* - The combination of rooms in the AV are separated from other AVs within the same fire area by regulatory fire barriers that are rated for at least 1 hour. The regulatory fire barriers that separate the AV from other AVs in the fire area provide for protection of safe-shutdown equipment in accordance with Appendix R, Section III.G.2. Except as discussed in Section 6.5 ("Deviation - Partial Fire Wall Between Component Cooling Water System Pumps"), if redundant safe-shutdown cables are located in the AV, they are protected by an electrical raceway fire barrier system throughout the AV (i.e., from regulatory fire barrier to regulatory fire barrier that establishes the AV boundary).~~

- ~~Watts Bar rooms 713-A2 (airlock), 713-A3 (titration room), 713-A4 (radiochemical lab), 713-A5 (counting room), and 713-A30 (airlock) are examples of the applicant combining and evaluating areas as a single AV. Fire is unlikely to spread from one room to the next, but, in any event, fire will not propagate beyond the fire barriers establishing the boundary of the AV. Electrical raceway fire barrier systems are installed to protect one train of safe-shutdown cables and are applied from AV fire barrier to AV fire barrier and do not stop at the intermediate walls.~~

- ~~*Sections of Large General Areas* - AVs consisting of sections of large general areas are separated from each other by "buffer zones." These buffer zones are wider than 20 feet. In large general areas where buffer zones are used that include intervening combustibles, enhanced automatic suppression and detection systems are installed in the large general area (refer to Section 6.4," Deviation - Intervening Combustibles"). If redundant safe-shutdown cables are located in the AV, one train is selected to be protected by an electrical raceway fire barrier system. The electrical raceway fire barrier system is applied throughout the AV (i.e., from AV boundary to AV boundary). An example of this type of AV is shown in Figures 1 and 2, below.~~



~~**Figure 1**~~



~~**Figure 2**~~

~~For example, elevation 737 ft 0 in. of the auxiliary building was subdivided into smaller sections to facilitate the fire safe-shutdown analysis. First, as shown in Figure 1, the 737 ft 0 in. elevation was split into two main AVs at column line A8. Example Volume 1 covers the area between column lines A1 to A8 and example Volume 2 covers the area between column lines A8 to A15. Each of these AVs includes a >20-foot buffer zone (737-A1BN and 737-A1AN) which forms the interface between the two volumes. This interface forms a third AV (shown in Figure 2) and consists of the area between column lines A6 to A10 and is approximately 42 feet wide.~~

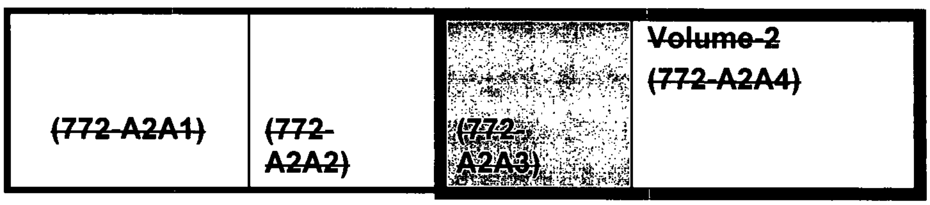
~~The applicant's post-fire safe-shutdown analysis methodology first evaluates the main AVs (Volume 1 and Volume 2). In each of these volumes, the applicant performed an evaluation to ensure compliance with Appendix R, Section III.G.2. Where cables of redundant safe-shutdown equipment are located in an AV, one train is selected for protection with an electrical raceway fire barrier system. The selected cables are protected from AV boundary to AV boundary. In this example, Train B cables are protected in the Volume 2 and Train A cables are protected in the Volume 1. If a Train B cable were to transition, it would be protected from the fire-rated fire barrier at A1 to the end of the AV at A8.~~

~~The applicant then evaluated the AV created by combining the Volume 1 and Volume 2 buffer zones (Volume 3). This evaluation addresses potential fires that may occur at the Volume 1 and Volume 2 interface and also addresses the potential for a fire to propagate across the interface. In performing this analysis, the applicant credited components and cables outside this third AV to the maximum extent practical in order to ensure that separation between redundant trains exceeded 20 feet. Where cables of redundant safe-shutdown equipment were located in this volume, one train was protected by a electrical raceway fire barrier system. The required safe-shutdown equipment cables are protected throughout the boundaries of Volume 3.~~

~~The applicant's evaluation process results in an overlap area of more than 20 feet where both trains of safe-shutdown equipment cables are protected. For example, if Train A cables were selected to be protected throughout Volume 3, both trains of safe-shutdown equipment cables would be protected in the Volume 2 buffer zone (column lines A-6 to A-8) because Train B cables are protected throughout Volume 2.~~

~~• *Sections of Large Rooms* - For AVs that consist of large room sections separated by an overlap region that is greater than 20 feet, the overlap region is considered to be part of both AVs. If the overlap region contains intervening combustibles, enhanced automatic suppression and detection systems are installed in the large room (refer to Section 6.4, "Deviation - Intervening Combustibles," for additional information). If redundant safe-shutdown cables are located in the AV, they are protected by an electrical raceway fire barrier system throughout the AV (i.e., from AV boundary to AV boundary). An example of this type of AV is shown in Figures 3 and 4, below.~~

~~**Figure 3**~~



~~**Figure 4**~~

~~Room 772-A2 (480-V board room 1B) is a large room subdivided into two AVs to facilitate analysis (Volume 1 and Volume 2). As shown in Figure 3 above, Volume 1 consists of room subdivision sections A2A1, A2A2, and A2A3, and as shown in Figure 4, Volume 2 consists of room subdivision sections A2A3 and A2A4. Section A2A3 is the overlap area that is part of both AVs. This overlap area was selected to provide a separation distance greater than 20 feet between the adjoining AVs.~~

~~In each of these AVs, the applicant performed an evaluation to ensure compliance with Appendix R, Section III.G.2. Where cables of redundant safe-shutdown equipment are located in the same volume, one train is selected for protection with an electrical raceway fire barrier system. The selected cables are protected from AV boundary to AV boundary. In this example, the only cables requiring fire barrier protection in Volume 1 and Volume 2 were located and protected in both AVs.~~

~~The applicant's proposed criteria for providing fire protection for safe-shutdown functions offers an equivalent level of fire safety to Section III.G. of Appendix R to 10 CFR Part 50 and is, therefore, acceptable.~~

~~3.2.2 Safe Shutdown - General Plant Areas~~

~~The applicant's methodology for assessing compliance with the separation/protection requirements of Section III.G of Appendix R consisted of~~

~~(1) determining the functions required to achieve and maintain safe shutdown~~

~~(2) producing shutdown logic diagrams that define minimum sets of systems capable of accomplishing each shutdown function~~

~~For each safety function, the major equipment required to accomplish that function was identified and arranged on the SDL in functional groups called "keys." These keyed blocks were then expanded by developing smaller logic diagrams called "equipment keys"; these identify the subsystems or components or both required to provide the specified function. The equipment keys, combined with the SDL diagram, identify the redundant paths available to achieve and maintain safe shutdown conditions in the event of fire.~~

~~(3) grouping specific plant locations into fire areas~~

~~(4) identifying for each area, one or more paths through the shutdown logic diagrams that will satisfy each required shutdown function~~

~~(5) developing functional criteria that defined the required equipment for the shutdown paths~~

~~(6) identifying power and control cables for shutdown-related equipment and associated circuits that are not isolated from shutdown cabling~~

~~From the SDL and associated equipment keys, TVA identified cables, in block diagram form, for required components. A required cable list was then generated which includes circuits to required equipment and circuits of equipment whose spurious operation could affect safe shutdown. Raceways that contain these required cables were then identified, and their locations documented. An interaction is defined as a place in the plant where redundant safe-shutdown paths are not separated in accordance with the requirements of Appendix R, Section III.G.2. Whenever an interaction was identified, it was documented and evaluated for its impact on safe-shutdown capability. An appropriate resolution was then determined and documented.~~

~~(7) relocating cables and equipment, providing fire barriers, fire detection and fire suppression systems so the separation/protection requirements of Appendix R, Section III.G would be met, or providing justification where deviations from these requirements occur~~

~~On the basis of this methodology and subject to the deviations from the requirements of Section III.G, the applicant's methodology conforms to the requirements of Appendix R to 10 CFR Part 50 and is, therefore, acceptable.~~

~~3.2.3 Safe-Shutdown Analysis~~

~~The applicant's safe-shutdown analysis demonstrated that sufficient redundancy exists for systems needed for hot and cold shutdown. The safe-shutdown~~

~~analysis included components, cabling, and support equipment needed to achieve hot and cold shutdown. Thus, in the event of a fire anywhere in the plant, at least one train of systems would be available to achieve and maintain hot shutdown and proceed to cold shutdown.~~

~~For hot shutdown at least one train of the following safe-shutdown systems would be available: auxiliary feedwater system, steam generator power-operated relief valves, reactor coolant system, and the chemical and volume control system. For cold shutdown, at least one train of the residual heat removal (RHR) system would be available. The RHR system would be used for long-term decay heat removal and provides the capability to achieve cold shutdown within 72 hours after a fire. The availability of these systems includes the components, cabling, and support equipment necessary to achieve cold shutdown. Support equipment includes the diesel generators and associated electrical distribution system, emergency river cooling water system, component cooling water system, and the necessary ventilation systems.~~

~~The applicant performed an electrical separation study to ensure that at least one train of such equipment is available in the event of a fire in areas that might affect these components. Safe-shutdown equipment and cabling were identified and traced through each fire area from the component to the power source. Associated circuits whose fire-induced spurious operation could affect safe shutdown were identified by a system review to determine those components whose maloperation could affect the safe-shutdown capability. Following their identification, such circuits were provided with a level of fire protection that is equivalent to that provided for redundant trains of required equipment.~~

~~The applicant's analysis indicated that the only area outside containment where redundant divisions are not adequately separated in accordance with Section III.G of Appendix R is the control building. Alternate shutdown measures are required for fires in the control building. If a fire should disable the main control room, the auxiliary control room (ACR), which is located in a separate fire area of the auxiliary building, would be available to achieve, and maintain the plant in, hot standby and subsequent cold- shutdown conditions. The control functions and indications provided at the ACR panel are electrically isolated or otherwise separate and independent from the main control room. Further discussion of the alternate shutdown capability is presented below in Section 3.3., "Alternative Shutdown."~~

~~On the basis of the results of its review, the staff finds that the systems identified by the applicant for achieving and maintaining safe shutdown in the event of a fire are acceptable. Additionally, the methodology used to ensure an adequate level of fire protection ifor these safe-shutdown systems is in accordance with or equivalent to that required by Section III.G. of Appendix R to 10 CFR Part 50 and is, therefore, acceptable.~~

~~3.2.3 Systems Required for Safe Shutdown~~

~~Shutdown of the reactor and reactivity control is initially performed by control rod insertion from the control room. Reactor coolant system (RCS) inventory and long-term reactivity control are maintained by varying charging and letdown flow through the RCS makeup and letdown paths. Decay heat removal during hot shutdown is accomplished by establishing secondary-side pressure control and supplying water to two of the four steam generators from one of~~

~~the redundant auxiliary feedwater pumps. Long-term heat removal to establish and maintain cold-shutdown conditions is provided by the residual heat removal (RHR) system.~~

~~Primary system pressure may be controlled by the pressurizer heaters (if available) or by varying charging flow and level to maintain RCS pressure. The applicant states that analyses and testing have been performed at similar plants which demonstrate that the use of charging to control pressure by varying RCS level provides an equivalent capability to that provided by the pressurizer heaters. The applicant submitted details regarding the referenced analyses and testing for the specific fire areas where such use may be required.~~

~~The systems selected by the applicant are capable of satisfying the post-fire safe-shutdown requirements of Sections III.G and III.L of Appendix R to 10 CFR Part 50, and are, therefore, acceptable.~~

~~3.3 Alternative Shutdown~~

~~3.3.1 Areas in Which Alternative Shutdown Is Required~~

~~The applicant's analysis has identified four areas of the control building which do not satisfy the separation requirements of Section III.G of Appendix R. Specifically, these areas are the main control room, the cable spreading room, and the two auxiliary instrument rooms. The alternate shutdown system developed by the applicant provides alternative shutdown capability for all areas of the control building, which includes the areas mentioned above.~~

~~3.3.2 Alternative Shutdown System~~

~~The alternative shutdown system uses existing plant systems and equipment identified in Section 3.2 above, and an auxiliary control room complex. No repairs or modifications are required to implement the alternative shutdown capability.~~

~~The auxiliary control room (ACR) complex is physically independent of the control building. Where required, electrical isolation of controls and indications provided on the ACR is achieved through the actuation of isolation/transfer switches. The ACR complex is divided into five independent rooms consisting of a Train A and Train B transfer switch room for each unit and the ACR. The ACR serves as the central control point during alternative shutdown from outside the main control room, and provides control and monitoring capability for redundant trains (Train A and B) of equipment required to achieve safe shutdown.~~

~~3.4 Alternative Shutdown Performance Goals~~

~~The alternative shutdown system described in Sections 3.4.1 – 3.4.5 was designed to enable the achievement of alternative shutdown performance goals outlined in Section III.L of Appendix R as follows:~~

~~3.4.1 Reactivity Control~~

~~Initial reactivity control is provided by the control rods, which are inserted by the reactor protection system. Additional shutdown margin is provided by~~

~~injecting borated water from the refueling water storage tank (RWST) into the reactor coolant system (RCS) via the charging pumps. Source range monitoring instrumentation is available in the ACR to monitor reactivity and ensure adequate shutdown margin.~~

~~3.4.2 Reactor Coolant Inventory~~

~~Control of the RCS inventory requires maintenance of reactor coolant pump (RCP) seal integrity, maintaining RCS pressure boundary integrity, and providing RCS makeup and letdown.~~

~~RCP seal cooling is required to maintain seal integrity and prevent an uncontrolled loss of reactor coolant inventory. RCP seal cooling will be achieved by diverting a portion of the charging flow to the RCP seals. The RCS pressure boundary is isolateded by isolating the normal and excess letdown lines. To prevent depressurization of the RCS, the solenoid valves in the reactor vessel head vent system are assured to remain closed.~~

~~RCS inventory is controlled by varying charging and letdown flow through RCS makeup and letdown paths. One of the redundant centrifugal charging pumps is required to provide makeup inventory to the RCS. The volume control tank (VCT) is required to provide a short-term supply of water for makeup of RCS inventory and RCP seal cooling. A suction path from the RWST is required to provide a long-term source of borated water for RCS makeup. If necessary, inventory may be removed from the RCS by way of the pressurizer power-operated relief valves (PORVs), discharging to the pressurizer relief tank (PRT), or discharging through the RCS head vent valves.~~

~~Reactor coolant makeup is usually available immediately following reactor trip from the charging system, except in a few fire locations where it is available within 75 minutes following reactor trip. The licensee has performed an analysis which demonstrates that makeup due to RCS leakage is not required for 75 minutes. For these scenarios, cooling to prevent RCP seal failure will be provided by the thermal barrier booster pumps located in a separate fire area. To preclude a boron dilution event, the RCPs will be stopped within 15 minutes of reactor trip.~~

~~3.4.3 Decay Heat Removal~~

~~RCS temperature from power operation to hot-shutdown conditions is controlled by the rate of heat removal from the reactor coolant to the secondary-side coolant and from hot shutdown to cold shutdown via direct heat transfer by the RHR system to the ultimate heat sink. During RCS cooldown to RHR entry conditions, heat will be removed from the reactor and transferred to the steam generators via natural circulation. The removal of decay heat from reactor trip to hot standby conditions requires one auxiliary feedwater pump supplying water to two of the four steam generators. The required makeup water supply can come from either the condensate storage tank (CST) or from emergency raw Ccooling Wwter (ERCW).~~

~~Two steam generators are required for cooldown. Control of steam generator inventory requires one Auxiliary Feedwater (AFW) pump, either the turbine- driven auxiliary feedwater pump (TDAFW) or one of the two motor-driven auxiliary feedwater pumps, drawing suction from the CST or ERCW, and the corresponding steam generator PORVs. Each motor-driven pump provides injection~~

~~flow to two steam generators: MDAFW 1-A-A to SG-1 and SG-2 and MDAFW 1-B-B to SG-3 and SG-4. The turbine-driven auxiliary feedwater pump (TDAFW) discharge may be aligned to any two steam generators. However, a supply of steam from SG-1 or SG-4 is required for TDAFW pump operation.~~

~~The CST is normally aligned to the suction of the AFW pumps through locked- open valves. After the CST has reached its low level as indicated by low pump suction pressure, the suction for the AFW system must be aligned to the ERCW system. For shutdown from the main control room, operators transfer AFW pump suction by manually opening the isolation valves corresponding to the operating AFW pump. During alternative shutdown from the auxiliary control room, AFW pumps will automatically transfer from the CST to the ERCW system.~~

~~The residual heat removal (RHR) system is required to provide the long-term heat removal capability necessary to establish and maintain cold-shutdown conditions. The establishment of RHR cooling requires one RHR pump, heat exchanger, and associated flowpath to provide RCS coolant flow to the primary side of the RHR heat exchanger; one component cooling system (CCS) pump and its associated flowpath to provide cooling to the secondary side of the RHR heat exchanger; and one essential raw cooling water (ERCW) pump and its associated flowpath to supply cooling water to the CCS heat exchanger. If the diesel generators are required to supply required power, an additional ERCW pump would be required for cooling purposes.~~

~~The applicant's post-fire shutdown analysis states that the pressurizer heaters are the preferred method of controlling RCS pressure, and will be used if available. If the pressurizer heaters are lost as a result of fire damage, RCS pressure will be controlled by using the charging system to vary the pressurizer level. The shutdown analysis also indicates that under certain fire conditions, the ability to depressurize the reactor using pressurizer spray and the PORVs may be lost. This scenario would require RCS pressure to be reduced by alternately filling and draining the pressurizer using the charging system.~~

~~3.4.4 Process Monitoring~~

~~Direct indication of process variables including reactor coolant hot-leg temperature (T-hot), reactor coolant pressure, pressurizer level, steam generator level and pressure, source range flux, charging header pressure and flow, volume control tank level indication, and decay heat removal system flow are provided at the auxiliary control room.~~

~~The applicant has requested a deviation to Appendix R requirements for instrumentation necessary to achieve alternative shutdown. Specifically, contrary to Appendix R requirements, the applicant has not provided wide-range steam generator level, tank level indication for the condensate storage tank and refueling water storage tank and RCS cold-leg temperature (T-cold). (Refer to Section 6.1, "Deviation - Required Instrumentation for Alternative Shutdown," for the staff's evaluation of the applicant's deviation request.)~~

~~3.4.5 Support Functions~~

~~The applicant submitted a listing of all required support functions. The TVA Fire Protection Report and the associated shutdown logic diagram identify the onsite electrical supply (diesel generators and distribution system),~~

~~environmental control (HVAC components required for hot standby), cooling water systems, and communications as required support functions. In Appendix A of WBN-OSG-031 R18, it states that ventilation cooling required to maintain hot standby is required for the main control room (MCR), reactor building, diesel generator (DG) building, 480-V transformer rooms, the TDAFW room, and the 713 ft 0 in. elevation of the auxiliary building. All other areas of the plant containing equipment required for safe shutdown would maintain acceptable temperatures for 72 hours if all ventilation were lost. The staff finds this acceptable.~~

3.5 Manual Operator Actions

The applicant's post-fire safe-shutdown analysis, and associated cable interaction studies, have identified a number of fire areas where operator actions to take manual control of equipment may be required to compensate for fire-induced equipment failures. On the basis of its analyses, the applicant performed Calculation No. WBN-OSG-165, R5, "Manual Actions Required for Safe Shutdown Following a Fire." This evaluation identified manual operator actions required to achieve safe shutdown in the event of fire in any plant area, established allowable operating times to accomplish these actions, and verified the feasibility of performance. A review of this calculation noted the following: (1) manual actions required for each plant area/zone for the "worst case" fire zone were identified; (2) the time estimates required to accomplish each manual action were verified by physical plant walkdowns; and (3) to either establish a shutdown path or compensate for fire damaged cables or equipment, the applicant's analysis credits the performance of one or more manual operator actions in areas/zones not requiring an alternative shutdown capability U1

~~The staff reviewed procedures necessary to implement this approach. The only operator action normally credited prior to control room evacuation is a reactor trip (scram). However, the applicant's Fire Protection Report credits two actions prior to control room evacuation: reactor trip and reactor coolant pump trip. In the event of fire in the control building, an immediate trip of the reactor coolant pumps is necessary to prevent overcooling caused by a spurious actuation of pressurizer spray valves. The feasibility and adequacy of the applicant's proposed approach for preventing a spurious actuation of pressurizer spray valves was adequately demonstrated during the July 1995 site visit and, therefore, is acceptable.~~

3.5.1 Safe-Shutdown Procedures and Manpower

The applicant has developed post-fire safe-shutdown procedures (AOI-30.2) for each fire zone. The staff found that these procedures identified necessary manpower requirements and contained sufficient guidance in the proper sequence for operators to achieve safe-shutdown conditions, and that the instructions for shutting down operating equipment were assigned in the proper sequence. Therefore, the staff finds the applicant's post-fire safe-shutdown procedure acceptable.

~~3.5.2 Repairs~~

~~The applicant states that repair activities (e.g., lifting/cutting leads, installing jumpers, and fuse replacement) are not required to achieve and maintain hot standby conditions. Additionally, the alternative shutdown~~

~~capability is capable of achieving cold-shutdown conditions without repairs. Repairs may, however, be necessary to achieve cold shutdown conditions as a result of fire in the following areas:~~

- ~~Rooms 757.0-A5 and 757.0-A24~~

  ~~Repairs required to ensure cold-shutdown capability in the event of fire in these rooms include the installation of an electrical jumper to power a second ERCW pump from 6.9-kV board 1-BD-211-A-A.~~

- ~~Rooms 692.0-A1A, -A1AN, and -A1BN (Col. Lines Q-U/A1-A10)~~
  - ~~Room 692.0-A1C~~
  - ~~Room 713.0-A1A~~
  - ~~Room 737.0-A3~~
  - ~~Room 757.0-A2~~

  ~~Required cold-shutdown repairs include the installation of electrical jumpers at the respective motor control centers (1-MCC-214-A1/9A-A and 1-MCC-214-B1/9A-B) and replacement of the power cable from the MCC to the room cooler.~~

- ~~Rooms 737.0A1A, - A1AN, and A1BN (Col. Lines Q-U/A1-A10)~~
  - ~~Room 757.0-A2~~
  - ~~Room 757.0-A5~~
  - ~~Room 757.0-A10~~
  - ~~Room 772.0-A6~~
  - ~~Reactor building~~

  ~~Cold shutdown repairs for fire in these areas include the installation of an electrical jumper and replacement of power and limit switch cables for RHR/RCS high-low pressure interface valves. The repairs are necessary to allow RHR/RCS high/low-pressure boundary valves 1-FCV-74-1-A, -2-B, -8-A, and/or -9-B to be opened for cold-shutdown capability.~~

~~Cold-shutdown repair activities include the installation of electrical jumpers in the ERCW and RHR systems. The applicant has identified the specific activities to be performed and has developed repair procedures to implement this capability. Additionally, materials necessary to accomplish the repairs are available on site.~~

~~The repair activities developed by the applicant to achieve cold shutdown conditions satisfy the requirements of Appendix R to 10 CFR Part 50 and are, therefore, acceptable.~~

~~3.6 Associated Circuits~~

~~The applicant has examined the potential impact of fire damage on associated circuits of concern. Associated circuits have been categorized by the applicant as Type I: Common Power Source, Type II: Spurious Actuation, and Type III: Common Enclosure.~~

~~3.6.1 Circuits Associated by Common Power Source~~

~~For circuits associated by a common power source, the applicant has identified all circuits supplied from a power source (i.e., switchgear, MCCs, and load~~

~~centers) that also powers a circuit of equipment required for post-fire safe shutdown. For the identified circuits, the coordination of electrical protection devices (e.g., fuses, circuit breakers, or relays) was verified to ensure that a fire-induced fault on a branch circuit of a required supply will be cleared by at least one branch circuit protective device before the fault current could propagate to cause a trip of any upstream feeder breaker to the supply.~~

~~To meet the separation requirements of Section III.G.2 of Appendix R, Generic Letter (GL) 86-10 states that multiple high-impedance faults (MHIFs) should be considered in the evaluation of electrical power supplies required for post-fire safe shutdown. The applicant has evaluated the affect of MHIFs on the post-fire safe-shutdown capability of Watts Bar Unit 1. This evaluation is contained in TVA Calculation No. WBPE VAR 9509001, "Appendix R - Multiple High-impedance Fault Analysis," Revision 1, dated September 20, 1995. The applicant's evaluation is similar to a methodology developed by the Philadelphia Electric Company (PECO) for evaluating MHIFs at the Peach Bottom Atomic Power Station. The PECO methodology, which uses the 60-second trip- point characteristic of the power supply feed protective device in lieu of the 1000-second trip-point characteristic, was approved by the staff in a safety evaluation dated April 12, 1989.~~

~~The applicant's evaluation of MHIFs is based on a phased approach. In Phase 1, a technical evaluation of all power sources required for post-fire safe shutdown was performed using the following assumptions: (1) all (100%) of the connected nonessential cables experience a high-impedance fault (HIF) condition simultaneously and (2) the HIF current has a value that is just below the 1000 second trip characteristic of the load protective device.~~

~~The pass/fail criteria used during this phase of the evaluation are (1) total board current including MHIF is less than the supply protective device trip characteristic at 1000 seconds or (2) total board current including MHIF is less than the supply protective device trip characteristic at 60 seconds.~~

~~With the exception of one 480-V shutdown board (480-V SDB 2A2-A), all required power sources at the 480-V ac level and above (i.e., 480-V MCCs, 480-V shutdown boards, and 6.9-kV switchgear) are capable of satisfying evaluation criterion 1 (i.e., 100% of nonessential cables faulted with the source protective device characteristic at 1000 seconds). In the event of fire in Fire Zone 737A1B, located on the 737 ft 0 in. elevation of the auxiliary building, 480-V shutdown board 2A2-A cannot satisfy criterion 1, but is capable of satisfying criterion 2 (100% of nonessential cables faulted with the source protective device characteristic at 60 seconds) with margin.~~

~~Power sources which did not satisfy the Phase 1 criteria were identified and appropriate procedures necessary to restore power were developed. None of the power sources falling into this category power time-critical loads (i.e., safe shutdown loads whose loss could not be tolerated for a short period of time until actions can be taken to restore power).~~

~~On the basis of the following facts, the applicant's evaluation of multiple high-impedance faults was found acceptable:~~

~~(1) The majority of safe-shutdown loads whose loss could impact safe-shutdown capability are powered from either a 6.9-kV or 480-V power source. As~~

~~currently configured and loaded, all required power sources associated with these voltage levels are capable of sustaining HIFs on all non-essential loads at the long-time (1000 second) trip characteristic of the supply breaker, with the exception of one 480-V ac shutdown board (480-V SDB 2A2-A). In the event of fire in all fire AVs except fire AV 737A1B, 48-0V SDB 2A2-A is also capable of satisfying this criterion. In the event of fire in this AV (737 A1B), SDB 2A2-A is capable of sustaining HIFs on all nonessential loads using the 60-second trip characteristic of the supply protective device.~~

~~(2) It is considered highly unlikely that all nonessential cables of a required power supply would be simultaneously faulted in a high-impedance condition for an extended period of time. This view is reflected in the staff's previous acceptance of the use of the supply protective device 60-second trip characteristic in evaluating the potential affects of MHIFs (refer to safety evaluation of the PECO analysis of MHIFs, dated April 12, 1989).~~

~~(3) Restoration procedures have been developed for power sources that have a potential for loss due to MHIFs. In no case are restoration procedures relied on for any power supply powering time critical loads (i.e., safe shutdown loads whose loss could not be tolerated for a short period of time until actions can be taken to restore power).~~

~~The applicant's evaluation of Type I associated circuits also considered multiple high-impedance faults that may be initiated as a result of fire. This evaluation considered the potential for multiple, concurrent high- impedance faults for each power source required for safe shutdown and is, therefore, acceptable.~~

~~3.6.2 Spurious Actuation~~

~~As part of a systems evaluation performed during the development of the shutdown logic and associated required cable lists, the applicant identified circuits whose fire-induced spurious actuation could affect the safe-shutdown circuits. During this phase of the analysis, components that must be prevented from spuriously operating were identified. These components were then listed in the shutdown logic and associated equipment keys. The applicant then evaluated the cable separation and protection provided for this equipment in the same manner as required circuits. All circuits which could cause undesirable spurious operations were identified and evaluated for potential fire damage. Additionally, if circuits for redundant components could be affected by a common fire, they were evaluated concurrently and corrective action was identified as needed.~~

~~3.6.3 Common Enclosure~~

~~To address the common enclosure-associated circuit concern, the applicant has evaluated all circuits that may share a common enclosure (e.g., cable tray, conduit, panel or junction box) with an Appendix R-required circuit. On the basis of its evaluation, the applicant concludes that the electrical protective equipment provided will ensure that electrical faults and overloads will not result in any more cable degradation than would be expected when operating conditions are below the setpoint of the electrical protective device.~~

~~On this basis, the applicant's methodology for assessing the potential effect of fire damage to nonessential associated circuits on the safe-shutdown capability of the plant was found to satisfy the requirements of Appendix R to 10 CFR Part 50, and is, therefore, acceptable.~~

~~3.6.4 High/Low-Pressure Interfaces~~

~~The applicant has identified the following as high/low-pressure interfaces: RHR/RCS isolation valves (1-FCV-74-1, 1-FCV-74- 2, 1-FCV-74-8, and 1-FCV-74-9); pressurizer PORV and block valves, excess letdown isolation valves (1-FCV-62-55 and 1-FCV-62-56); normal letdown isolation valves, reactor head vent and isolation valves, and the safety injection system/RHR interface valve. During its evaluation, the applicant considered the potential for multiple circuit faults.~~

~~To prevent fire-initiated cable faults from causing a spurious operation of the RHR isolation valves, power is removed during plant operation.~~

~~The applicant states that cables for the pressurizer PORV and its associated block valves are not subject to concurrent damage from a common fire. Where necessary, fire barrier wrap is used to protect cables of at least one valve. In the event of fire requiring alternative shutdown (i.e., a control building fire), the applicant states that the PORV block valves can be closed and isolated.~~

~~To prevent spurious operation of the remaining high/low-pressure interfaces in the event of fire in areas other than the control building, the applicant states that cables of redundant valves in the same high/low-pressure interface line are not subject to damage from a common fire. In the event of a fire in the control building, the applicant states that spurious operation of these valves will be prevented by operator actions to deenergize and isolate circuits of the affected valves.~~

~~The applicant's approach is an acceptable means of preventing spurious operations of high/low-pressure interfaces.~~

3.7 <u>Fire Barriers Used To Separate Redundant Safe-Shutdown Functions Within the Same Fire Area</u>

3.7.1 Raceway and Cable Tray Fire Barriers

Cable raceway that requires separation by fire-rated barriers at Watts Bar may be protected by either 1-hour or 3-hour fire-rated barrier systems. The applicant will use a 1-hour fire-rated barrier system if automatic detection and suppression are installed in the area and a 3-hour fire-rated barrier system if automatic suppression is not installed in the area. Currently, the applicant has proposed to use Thermo-Lag 1-hour fire-barrier raceway assemblies to separate redundant safe-shutdown functions within the same fire area.

By letters dated October 16, 1992; February 10, 1993; June 25, 1994; and March 22, 1995, the applicant proposed to use Thermo-Lag 330-1 and 770-1 materials to construct the required 1-hour and 3-hour fire-rated barrier protection for one train of safe-shutdown capability and to meet the fire separation requirements specified for redundant safe-shutdown trains in Section III.G of Appendix R to 10 CFR Part 50. By letters dated July 9, 1994; December 23, 1994; and March 29, 1995, the applicant submitted the results of the qualification testing it did to demonstrate that its proposed Thermo-Lag fire- barrier installations will satisfy the 1-hour and 3-hour fire-resistive requirement of Appendix R, Section III.G.

The staff audited the construction of the fire endurance test specimens at the applicant's contract testing laboratory (Omega Point Labs, San Antonio, Texas) during the weeks of February 13, 1993, and July 25, August 1, August 22, and October 17, 1994. During these visits, the staff observed the erection of raceway configurations, installation of test instrumentation, installation of penetration seals, and the construction and application of Thermo-Lag 330-1 fire barrier materials. The staff also observed the test laboratory's and the applicant's quality control (QC) and quality assurance (QA) activities.

The staff observed fire endurance tests on December 21 and 22, 1992; January 7, March 31, April 1, 6 and 7, 1993; September 7, 8, and 20, 1994; October 18, 19, and 27, 1994; and November 17, 1994. The staff observed the test setups, the fire exposure and hose stream tests, and the collection of thermocouple data. The staff also observed the condition of the fire barrier after the fire exposure and hose stream tests.

3.7.2 Thermo-Lag 330-1 Fire Barrier Materials

Thermo-Lag 330-1 used in panels, conduit preshapes, and trowel-grade materials, is a compound which goes through a sublimation process when exposed to fire. According to Thermal Science, Incorporated (TSI), the manufacturer of Thermo-Lag 330 fire barrier materials, under exposure to fire, the temperature of sublimation is attained. Once sublimation occurs, the Thermo-Lag material changes to a vapor. The sublimate vapors given off by the Thermo-Lag materials go through an endothermic decomposition process which absorbs heat from the fire. During the pyrolysis of the binder system, a char layer is formed which is composed of small interconnecting cells having a large surface area. This combined effect makes the endothermic decomposition process more efficient. The ability of the char layer to attain high temperatures further results in re-radiation of energy and a reduced heat transfer coefficient. The low conductivity of the light cellular char structure also provides an insulative function.

For its Phase 1, Conduit and Junction Box Fire Barrier Test Program, the applicant used Thermo-Lag materials extracted for Watts Bar site stock. Each Thermo-Lag 330-1 V-ribbed panel was 5/8-inch ± 1/8-inch thick (nominal) by 48 inches wide by 78 inches long, with stress skin monolithically adhered to the panel on one face. The stress skin is installed adjacent to the surface of the protected commodity (e.g., a conduit or a junction box). In addition to the panels, the applicant used preformed conduit sections (nominally 5/8 inch thick by 3 feet long and 3/8 inch thick by 3 feet long). All Thermo-Lag 330-1 panels and conduit preformed sections were measured, saw cut, and installed onto the respective test specimens by the applicant's craft personnel using approved Watts Bar drawings, procedures, and specifications.

Among the other materials used were Thermo-Lag 330-1 trowel-grade material, 16-gauge stainless steel tie-wire, and stainless steel stress skin (type 304, plain weave).

For its Phase 2, Cable Tray and Unique Configuration Test Program, and its Phase 3, Thermo-Lag 3-Hour Electrical Raceway Fire Barrier Systems, the applicant used Thermo-Lag materials supplied directly by TSI. The Phase 2 fire barrier materials were confirmed by the applicant's receipt inspection program to have the same basic physical attributes as those materials used during the Phase 1 fire barrier test program. Thermo-Lag 770-1 fire barrier mat material was used to overlay the nominal 1-1/4-inch-thick Thermo-Lag 330-1 panels and conduit preshapes. These Thermo-Lag 330-1 panels and conduit preshapes had stress skin monolithically adhered to both the outer and inner faces of the material. The Thermo-Lag 770-1 fire barrier mat material is 3/8- inch thick with a different size carbon fiber fabric mesh monolithically adhered to each face of the mat. The side of the mat material that is installed away from the protected raceway is covered with a carbon fiber fabric mesh having one opening per square inch. The side of the mat installed closest to the protected raceway is covered with a carbon fiber fabric mesh having 15 openings per square inch; this mesh was used to reinforce joints.

3.7.3 Fire Tests Methods Used To Qualify the Watts Bar Fire Barriers

The external fire exposure used to evaluate the Watts Bar Thermo-Lag raceway fire barrier system is described in American Society of Testing and Materials (ASTM) Standard E-119-1988, "Standard Fire Tests of Building Construction and Materials." The test specimens described below were exposed to a test fire for either a 1-hour or a 3-hour duration under the ASTM E-119 standard time-temperature curve. The test furnace is designed to allow the test assembly to be uniformly exposed to the 1-hour specified time-temperature conditions. The furnace used to test the Watts Bar fire barrier test specimens was fired with symmetrically located natural gas burners designed to allow and even heat flux distribution across the surface of the test assembly.

The temperature average within the furnace is the mathematical average of the thermocouples (TCs) located symmetrically within the furnace and positioned approximately 12 inches from representative surfaces of the test assembly. The exact positioning of the furnace TCs allowed the average fire exposure across the entire test assembly to be determined. These TCs had the proper time constant and conformed to the ASTM E-119 standard. The furnace temperature during a test is controlled so that the area under the time-temperature curve is within 10 percent of the corresponding area under the ASTM E-119 standard time temperature curve for the 1-hour fire exposure period and within 5 percent of the 3-hour fire exposure period. As much as possible, the furnace pressure was controlled to be approximately neutral with respect to the laboratory atmosphere, measured at the vertical mid-height of the test specimen.

3.7.4 Acceptance Criteria for Fire Endurance Test

The objective of the applicant's Thermo-Lag Fire Endurance Test Program was to qualify a protective fire barrier system that can be generically applied at the applicant's nuclear power plants. The tests were performed to satisfy the requirements for fire testing these electrical raceway fire barrier systems (ERFBSs) as detailed in UL Subject 1724, "Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems," Issue No. 2, August 1991, and NRC GL 86-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barriers Systems Used To Separate Redundant Safe Shutdown Trains Within the Same Fire Area."

The acceptance criteria for this test program were as follows:

(1) The exterior surface temperature of each electrical raceway shall be recorded at the cold side of the barrier. If the average recorded temperature of the exterior raceway TCs does not exceed 250 °F (139 °C) above their initial temperature and no individual TC exceeds its initial temperature by more than 325 °F (181 °C), the ERFBS shall be acceptable for use with any type of cable.

(2) The TCs located on the bare copper conductor (#8 American Wire Gauge (AWG) installed inside the electrical raceway shall be recorded. The highest temperature of TCs rises above its initial temperature rise and average temperature rise above the initial temperature shall be recorded for each ERFSB.

(3) Immediately (within the 10 minutes following the fire endurance test), accessible surfaces of the ERFBS test specimen shall be subjected to the cooling, impact, and erosion effects of a hose stream delivered through a 1-1/2-inch fog nozzle set at a discharge angle of 30° with a nozzle pressure of 75 psig and a minimum flow of 75 gallons per minute. During the test, the nozzle orifice shall be positioned no more than 5 feet from the test specimen.

3.7.5 Placement of Thermocouples in Test Assemblies

The installation of the test instrumentation wiring and the placement of the TCs on the 1-hour and 3-hour fire test assemblies was reviewed. Internal temperatures of the conduits were measured using TCs placed every 6 inches on a No. 8 AWG bare copper conductor. To read external temperatures, TCs were installed on the outside of the conduits every 6 inches. On cable trays, TCs were installed every 6 inches on the cable tray side rails. When individual cable trays did not contain a cable fill, a No. 8 AWG bare copper conductor was routed along the entire length of the cable tray and attached to the top of the rungs in the center of the tray. The TCs were located every 6 inches along this bare copper conductor. For the cable trays that contained cables (except Test Assembly 2-3, Specimen 3, an 18-inch-wide cable tray with solid metal cover), TCs were attached to a No. 8 AWG bare copper conductor attached to the bottom of the cable tray rungs on their centerline. In addition, a second No. 8 AWG bare copper conductor was installed on top of the cable fill down the center of the tray. These copper conductors had TCs attached to them every 6 inches.

All TCs used on these test assemblies were 24 GA, type K, Chromel-Alumel Teflon insulated, except on Test Assembly 1-1. These TCs were Fiberglas- insulated TC wire. This type of wire experienced moisture saturation during the fire testing of Test Assembly 1-1. The moisture saturation caused artificially high temperature readings to be measured on the No. 8 AWG bare copper installed internal to the conduit test specimens.

Test Assembly 1-1 had TCs placed every 6 inches on the bare 8 AWG bare copper conductor routed inside the air drop configurations of 1-inch-diameter conduit and 2-inch-diameter conduit. The 5-inch-diameter conduits had TCs placed every 12 inches on the bare No. 8 AWG bare copper conductor. TCs were placed every 12 inches along the bottom exterior surface of each conduit.

Test Assembly 1-2 was not instrumented with TCs on the exterior of the conduit surface as specified by GL 86-10, Supplement 1. The applicant followed the guidance of UL Subject 1724, "Outline of Investigation for Fire Tests for Circuit Protective Systems," Issue No. 2, dated August 1991. Internal temperatures of the conduits were measured with TCs placed every 6 inches on a No. 8 AWG bare copper conductor.

The staff concluded that the applicant's criterion for placing of TCs used in this test program except for Test Assemblies 1-1 and 1-2 conforms to the guidance of GL 86-10, Supplement 1, and, therefore, is acceptable.

3.7.6 Test Specimen Design and Construction

3.7.6.1 Phase 1 - Conduit and Junction Box Program

Test Assembly 1-1 - Description

This test assembly consisted of four individual configurations of conduit loops (two of 5-inch-diameter conduit and two of 1-inch-diameter conduit and two air drop configurations of 2-inch diameter). Conduits used were standard weight galvanized steel. Other conduit fittings used in constructing these test specimens included 1-inch and 5-inch malleable steel lateral bend (LB) condulet bodies; 1-inch, 2-inch, and 5-inch rigid galvanized steel conduit couplings; and 1-inch, 2-inch, and 5-inch rigid galvanized steel short radius 90° conduit elbows. Each conduit loop extended downward approximately 36 inches through the test deck, into a 90° condulet elbow with its long side vertical, through a horizontal conduit run of approximately 73 inches, into a 90° standard conduit radial bend and back up through the test deck. Each air drop assembly extended down through the test deck, into a 90° standard conduit radial bend where the air drop began. The air drop terminated approximately 36 inches away from its origination point and entered a second vertical section of conduit extending up through the test deck. The bottom of the standard radial bend in each air drop was approximately 21 inches below the bottom surface of the test deck. The second vertical conduit section extended approximately 6 inches below the lower surface of the test deck.

The ERFBSs for the LB condulets were formed from Thermo-Lag 330-1 ribbed panels (5/8-inch nominal thickness). The ribs were flattened; separate pieces were cut for the top, bottom, and each side, and were sized to fit each condulet. The edges of the bottom, back, and two sides of the condulet fire barrier were prebuttered with Thermo-Lag 330-1 trowel-grade material. The inside surfaces of the condulet fire barrier enclosure were prebuttered with trowel-grade material and then fitted onto the condulet. The spaces between the condulet and the fire barrier were filled with a combination of Thermo-Lag panel pieces and trowel-grade material. The top and end pieces were prebuttered with trowel-grade material and installed.

The conduits were enclosed with Thermo-Lag 330-1 preshaped sections (5/8-inch thickness). Individual wedge-shaped sections were cut from the conduit preshaped fire barrier material to form the ERFBS around the 90° conduit radial bends. All the interior surfaces, joints, and seams of the straight conduit preshaped sections and the wedge sections were prebuttered with trowel-grade material and fitted to the conduit.

The air drop conduit sections were enclosed by the same fire barrier construction methods used for the conduits, except that the air drop section between the air drop conduits was enclosed and connected with two conduit preshaped sections held together with stainless steel tie-wire. These conduit preshapes were prebuttered with trowel-grade material where they connected to the air drop conduits.

The entire test assembly was skim-coated with trowel-grade material (approximately 1/16-inch dry thickness). After the skim-coat was dry, one 1-inch-diameter conduit, one 5-inch-diameter conduit, and one 2-inch-diameter air drop were wrapped with stainless steel wire mesh (ASTM E-437, type 304 stainless steel, knitted mesh wire cloth, 60 density, 0.011-inch diameter wire). All conduit loops and air drops were banded with 1/2-inch stainless steel bands. These bands were spaced no more than every 6 inches on the straight conduit preshaped sections, no more than 4 inches on the curved conduit preshaped sections, and as needed on the LB condulets. On the condulets, sheet metal edge guards were used with the stainless steel bands.

<u>Test Assembly 1-2 - Description</u>

The configuration of this test assembly was identical to that of Test Assembly 1-1.

The ERFBSs for the LB condulets were formed by the "score and fold" method from a single piece of Thermo-Lag 330-1 ribbed panel with the ribs flattened to make the panel for each LB condulet. The material was scored to the internal stress skin and then was folded along the scored lines into a box configuration. These LB condulet boxes were internally prebuttered to the condulet with trowel-grade material and secured to the condulet with stainless steel tie-wires. The single joint formed by the stress skin overlap on the bottom of each LB condulet was stitched closed through the stress skin with stainless steel tie-wire.

The conduits were enclosed with Thermo-Lag 330-1 preshaped sections (5/8-inch nominal thickness). Straight conduit preshapes were scored in several locations to facilitate bending the preshaped section to conform to the curvature of the 90° radial conduit bend and the air drop sections. In several locations along the radial conduit bends, the internal stress skin was torn. External stress skin overlapped the torn skin by 1 to 2 inches. All the interior surfaces, joints, and seams of the straight and bent conduit preshaped sections were prebuttered with trowel-grade material and fitted to the conduit.

The air drop ERFBSs were constructed by means of the same techniques used to construct the Test Assembly 1-1 air drop ERFBSs.

The upgrade techniques used on this test assembly included covering a 1-inch diameter conduit, a 5-inch-diameter conduit, and a 2-inch-diameter air drop with a nominal 3/8-inch-thick Thermo-Lag 330-1 conduit preshaped overlay. The LB condulets were upgraded with Thermo-Lag panels which had a thickness between 1/4 and 3/8 of an inch. The ribs on these panels were flattened. All the interior surfaces of the LB panel pieces and the conduit preshaped conduit sections were prebuttered with trowel-grade material before installation. These test specimens were then skim-coated with trowel-grade material (approximately 1/16-inch dry thickness). Stainless steel tie-wire was applied with maximum spacings of 6 inches on the straight conduit sections, 4 inches on the curved conduit sections, and as needed on the LB condulet boxes.

The remaining three conduit and air drop test specimens were upgraded by wrapping them with the same stainless steel mesh as was used on Test Assembly 1-1. The stainless steel mesh was held in place with stainless steel tie-wire. These tie-wires had maximum spacings of 6 inches on the straight conduit sections, 4 inches on the curved conduit sections, and as needed on the LB condulet boxes. Trowel-grade material was applied over the mesh until a minimum 1/4-inch, maximum 3/8-inch, dry thickness was achieved.

Test Assembly 1-3 - Description

This test assembly consisted of four individual conduit loop configurations of 1-inch, 2-inch, 3-inch, 4-inch, and 5-inch-diameter conduits. Conduits used in these assemblies were standard weight galvanized steel. Other conduit fittings used in the construction of these test specimens included 1-inch, 2-inch, 3-inch, 4-inch, and 5-inch malleable steel LB condulet bodies; 1-inch, 2-inch, 3-inch, and 4-inch rigid galvanized steel conduit couplings; and 1-inch, 2-inch, 3-inch, and 4-inch rigid galvanized steel short radius 90° conduit elbows. Each conduit loop extended downward approximately 36 inches through the test deck, into a 90° condulet elbow with its long side vertical, through a horizontal run of approximately 108 inches, into a 90° standard conduit radial bend and back up through the test deck. A single trapeze-type Unistrut hanger was fabricated to support the horizontal section of the four looped conduits. The hanger was situated at the center line of the horizontal conduit runs. The plates on top of the hanger were insulated from the steel deck by a 4-inch-thick block of calcium silicate board.

The application of the baseline Thermo-Lag 330-1 fire barrier system to these conduits and LB condulets used the same techniques that were used for Test Assembly 1-2. Except for the 3-inch and the 2-inch-diameter conduits, they were enclosed preshaped sections that had a nominal 3/8-inch thickness.

For the 1-inch, 2-inch, and 3-inch LB condulets, the baseline Thermo-Lag fire barrier system was overlaid with 3/8-inch-thick Thermo-Lag 330-1 ribbed panels which had the ribs flattened. The 1-inch, 2-inch, and 3-inch conduits were upgraded with a 3/8-inch-thick preshaped overlay. All the interior surfaces, joints, and seams of the LB panel pieces and the preshaped conduit sections were prebuttered with trowel-grade material before installation. Stainless steel wire mesh was applied, in a single layer, over the baseline overlay fire barrier material in the 1-inch, 2-inch, and 3-inch-diameter conduit radial bend sections and the nominal 5/8-inch-thick baseline fire barrier installed on the 4-inch-diameter conduit radial bend section. The mesh was then covered with a skim-coat (approximately 1/8-inch thick) of trowel-grade material. Stainless steel tie-wire was applied with maximum spacings of 6 inches on the straight conduit sections, 4 inches on the curved conduit sections, and as needed on the LB condulet boxes.

Test Assembly 1-4 - Description

This assembly consisted of three conduit loop configurations (3-inch steel, 3-inch aluminum, and 1-1/2-inch steel) and two tube steel configurations (2-inch and 4-inch). Other conduit fittings used in the construction of these test specimens included 3-inch and 1-1/2-inch malleable steel lateral bend condulet bodies, 3-inch aluminum lateral bend condulet body, 3-inch and 1-1/2-inch rigid galvanized steel conduit couplings, 3-inch aluminum conduit couplings, 1-1/2-inch and 3-inch rigid galvanized steel short radius 90° conduit elbows, and a 3-inch aluminum short radius 90° conduit elbow. Each conduit loop extended downward approximately 36 inches through the test deck, into a 90° condulet elbow with its long side vertical, through a horizontal run of approximately 108 inches, into a 90° standard conduit radial bend, and back up through the test deck. Each tube steel configuration extended down through the test deck, 36 inches below the lower surface of deck and then ran horizontally for 30 inches. A single trapeze-type Unistrut hanger was fabricated to support the horizontal section of the four looped conduits. The construction and placement of this support was the same as for the support described for Test Assembly 1-3 above.

The baseline ERFBS for the 3-inch steel LB condulets was formed using the single-piece score-and-fold method. This baseline ERFBS was constructed out of a 5/8-inch-thick Thermo-Lag panel. The baseline fire barrier enclosure for the 1-1/2-inch steel LB condulet was formed using the same single-piece score- and-fold method that was used on the 3-inch steel LB condulet. However, the baseline fire barrier used on this condulet was constructed from a 3/8-inch-thick Thermo-Lag panel (see Test Assembly 1-2 for more details on the construction methods used for the condulet ERFBS). The baseline ERFBS for the 3-inch-diameter aluminum LB condulet was formed by cutting each side individually from 5/8-inch-thick panels with the ribs flattened. Before installation, each piece was prebuttered on the inner surfaces, joints, and seams with trowel-grade material. The condulet was prebuttered with trowel-grade material, and the fire barrier enclosure was held in place on the condulet with stainless steel tie-wire.

The two 3-inch-diameter conduits and the 1-1/2-inch-diameter conduits were enclosed with Thermo-Lag 330-1 preshaped sections (nominal 5/8-inch-thick material installed on the 3-inch conduits and 3/8-inch-thick material installed on the 1-1/2-inch conduit). The techniques used for installing the baseline fire barrier material on these conduits were the same as those used to construct Test Assembly 1-2.

The upgrade techniques included the installation of an additional layer of 3/8-inch-thick Thermo-Lag panel on the 1-1/2-inch LB condulet. This overlay was constructed using a single-piece score-and-fold method. All inner surfaces of the LB overlay were prebuttered with trowel-grade material prior to installation. The 1-1/2-inch-diameter conduit was overlaid with 3/8-inch Thermo-Lag conduit preshaped sections. The interior surfaces of each conduit preshaped overlay section were prebuttered with trowel-grade material before its installation. In the radial bend section of the 1-1/2-inch-diameter conduit, a single layer of stainless steel wire mesh was wrapped over the fire barrier material and held in place with temporary tie-wires. The wire mesh was then skim-coated with trowel-grade Thermo-Lag material (approximately 1/8-inch thick).

Stainless steel tie-wires were then installed on all the configurations, with the exception of the 3-inch-diameter aluminum conduit. Each tie-wire location had a maximum spacing of 6 inches on the straight conduit sections, 4 inches on the radial bend sections, and as needed on the LB condulets. On the 3-inch-diameter aluminum conduit, 1/2-inch-wide stainless steel bands were installed with similar spacing as used for the tie-wire. On the condulets, sheet metal edge guards were used with the stainless steel bands.

Test Assembly 1-5 - Description

This assembly consists of five steel junction boxes (JBs) (6 in. by 6 in. by 6 in., 20 in. by 12 in. by 8 in., 12 in. by 12 in. by 8 in., 18 in. by 12 in. by 12 in., and 24 in. by 18 in. by 12 in.), four conduit specimens (1-inch, 2-inch, 3-inch, and 5-inch diameter) interconnecting the JBs, and one lateral side (LS) condulet installed in the 2-inch conduit configuration. The conduits used were standard weight rigid steel. Each JB was affixed to the concrete test slab with sleeve anchors, and the conduit runs were connected between the JBs. The conduit hangers, consisting of a Unistrut material approximately 12 inches long, were affixed to the concrete test slab with sleeve anchors at the midpoint of the 3-inch and the 5-inch-diameter conduit runs and at the midpoint of the one section of the 2-inch-diameter conduit run. The 5-inch-diameter conduit interconnected JB5 (24 in. by 18 in. by 12 in.) and JB4 (18 in. by 12 in. by 12 in.) with a horizontal run of 66 inches. JB3 (12 in. by 12 in. by 8 in.) was interconnected to JB2 (20 in. by 12 in. by 8 in.) by a 36-inch horizontal run of 3inch-diameter conduit. JB4 was interconnected to JB2 and JB1 (6 in. by 6 in. by 6 in.). JB4 was interconnected to JB1 by a 42-inch horizontal run of 1-inch-diameter conduit, and JB4 was interconnected to JB2 through an L-shaped 2-inch-diameter conduit configuration with a total conduit run, including the LS condulet, of 57 inches.

The ERFBS for the LS condulet for the 2-inch-diameter conduit was constructed from a single piece of Thermo-Lag 330-1 ribbed panel which had the ribs flattened. The panel (nominally 5/8-inch thick) was cut and scored to fit snugly around the LS condulet, and sufficient stress skin was left in place on the panel edges to overlap onto the concrete test slab 2 to 3 inches. The condulet and panel were prebuttered; the interior surfaces of the ERFBS and the ERFBS was fitted around the LB condulet. The ERFBS was secured to the concrete slab with sleeve anchors. All joints and seams were prebuttered with trowel-grade material, and a single piece of stainless steel stress skin was cut and formed to fit over the condulet ERFBS and lap over onto the concrete slab. The stress skin overlay was held in place by the base plate and the sleeve anchors. The base plate for this ERFBS was constructed of a 5/8-inch panel cut to fit around the LB condulet ERFBS. The stress skin overlay was skim-coated with a 1/8-inch layer of trowel-grade material.

The ERFBSs constructed for JB1, JB3, and JB4 were individually constructed from a single piece of 5/8-inch-thick Thermo-Lag panel using the score-and-fold method. The methods used to construct these ERFBSs were the same as those used to construct the LS condulet fire barrier discussed above. However, the ERFBS for JB3 had a 3-1/2 inch wide by 4-1/2 inch-long by 5/8- inch-deep slot cut into it. This slot simulated a repair to the fire barrier. The repair patch was from a 5/8-inch-thick panel and fit in the slot.

The ERFBS for JB2 had four equally spaced 1/4-inch-diameter bolts attached to the hinged front cover to hold the front of the fire barrier enclosure in place. The sides of this fire barrier enclosure (nominally 5/8-inch thick) were formed by using the single-piece score-and-fold method. The sides were formed to allow the stress skin to overlap onto the concrete slab by 3 inches. The sides of the JB and the internal surfaces of the ERFBS were prebuttered with trowel-grade material. The fire barrier was installed on the JB and held in place with stainless steel tie-wire. A filler panel was cut from a 3/8-inch panel to fit inside the edges of the side fire barrier pieces and to form a solid base for the external front piece. The front piece, made out of 5/8-inch-thick Thermo-Lag panel, had a 2-inch stress skin overlap that was stapled to the sides after the front was installed. Both the filler panel and the external front panel were prebuttered with trowel-grade material before installation. The front and filler pieces were held in place by nuts and fender washers threaded onto the 1/4-inch bolt in the JB lid. The bolts were cut flush with the nut, and the nut was covered with trowel-grade material. A 4-inch-square piece of stress skin was stapled over the area in which the nuts are located, and a layer of trowel-grade material was applied over the stress skin. The sides of the ERFBS were attached with Thermo-Lag backing plates and sleeve anchors. (For discussion of backing plates, refer to construction description of the LS condulet above.) The edges of the ERFBS were filled with trowel-grade material and the entire enclosure was skim- coated with an additional layer of trowel-grade material (approximately 1/8-inch thick).

JB5 was protected by a fire barrier enclosure installed in the same way as the one for JB2, except that the sides were constructed from two pieces of panel instead of from one continuous panel piece.

The baseline ERFBS installed on the 5-inch and 1-inch conduits was constructed using 5/8-inch-thick conduit preshapes. The baseline ERFBS for the 2-inch and 3-inch conduits was constructed using 3/8-inch-thick conduit preshapes. All conduit and interior fire barrier surfaces, joints, and seams were prebuttered with trowel-grade material before installation.

The 1-, 2-, and 3-inch conduits were upgraded using a 3/8-inch-thick conduit preshape overlay. All interior surfaces, joints, and seams of the overlay sections were prebuttered.

All conduits were skim-coated with trowel-grade material and smoothed. Once the skim-coat had cured, stainless steel tie-wires were installed on all the conduits with maximum spacing of 6 inches.

Test Assembly 1-6 - Description

This assembly consisted of one steel JB (48 in. by 36 in. by 12 in.) and three 4-inch-diameter conduit and LB condulet test specimens. The conduits used to construct this test assembly were rigid galvanized steel. Two stanchions of 4-inch-square steel 30 inches long were fastened to the concrete test slab with concrete anchors. The JB was affixed to these stanchions, and the individual conduit runs were connected to the JB. The three parallel conduits and LB condulets with the long side horizontal had a horizontal run of 54 inches.

The fire barrier application techniques used to construct LB condulet ERFBS were the same as those used to construct the LB condulet ERFBS described for Test Assembly 1-2. The ERFBS for these 4-inch condulets was constructed from 5/8-inch-thick Thermo-Lag panel.

The JB had 12 equally spaced 1/4-inch-diameter bolts attached to the hinged front cover to hold the front of the ERFBS in place. The baseline ERFBS was formed from 5/8-inch-thick Thermo-Lag panels with the ribs flattened. The sides and the front of the enclosure were constructed using separate panel pieces. The fire barrier material applied to the end of the JB where the conduits entered was cut down the middle and then cut out to fit around the conduits. The stress skin of these two pieces was tied together with tie-wire, and then the seam was prebuttered with trowel-grade material. The sides of the JB and the internal surfaces of the sides of the ERFBS were prebuttered with trowel-grade material. The fire barrier was installed onto the JB and held in place with stainless steel tie-wire.

The front cover panel piece was cut to fit over the edges of the side panels. This front piece had a 2-inch overlap of stress skin that was stapled to the side pieces. A hole was cut out of the front piece to accommodate the handle of the JB cover. A fire barrier enclosure for the handle was constructed out of a single piece of Thermo-Lag using the single-piece score-and-fold method. This box enclosure had a 2-inch stress skin overlap. This box enclosure was placed on the handle before the front panel was attached to the JB. The front panel was prebuttered with trowel-grade material before installation and was held in place by nuts and fender washers threaded onto the 1/4-inch bolts in the JB cover. The sides of the fire barrier enclosure were attached with Thermo-Lag backing plates and sleeve anchors. (For a discussion of backing plates, refer to construction description of the LS condulet for Test Assembly 1-5 above.)

The conduit fire barriers were constructed from 5/8-inch-thick conduit pre- shapes. The fire barrier application methods used were the same as those used to apply the baseline fire barrier conduit preshapes to Test Assembly 1-2 conduits. No upgrades were applied to these conduits. The 4-inch-diameter conduits were skim-coated with trowel-grade material and smoothed. Once the skim-coat had cured, stainless steel tie-wires were installed on all the conduits with maximum spacing of 6 inches.

An overlay of 3/8-inch-thick Thermo-Lag panel was applied to the JB in the same manner as the first layer. The bolts were cut flush with the nut and trowel-grade material was applied to cover the nut. A 4-inch-square piece of stress skin was stapled over the nuts, and a layer of trowel-grade material was applied over the stress skin. The edges of the fire barrier enclosure were filled with trowel-grade material and the entire enclosure was skim- coated with an additional trowel-grade layer (approximately 1/8-inch thick).

3.7.6.2 Phase 2 - Cable Tray and Unique Configurations Test Program

Test Assembly 2-1 - Description

This test assembly consisted of (1) three 18-inch-wide standard weight steel cable trays with 4-inch side rails and rungs spaced on 6-inch centers and (2) a 3-inch-diameter rigid steel conduit. The cable trays and conduit test specimens were configured in an L-shape below the test deck. Each raceway extended 36 inches downward into the furnace, made a 90° bend, and turned into a horizontal run. Each raceway had a 72-inch horizontal run before penetrating the furnace wall. In Test Specimen 1, the cable trays had a varied cable fill: one cable tray had a 100-percent random cable fill (approximately 69.36 lb/linear foot); the second tray was filled with one layer of cables (approximately 6.24 lb/linear foot). The third tray in

Test Specimen 1 and the steel conduit (Test Specimen 2) did not contain any cables.

The 1-hour ERFBS for Test Specimen 1 (the three cable trays) was constructed with nominal 5/8-inch-thick Thermo-Lag 330-1 panels. The bottom and side pieces of all of the baseline cable tray ERFBS were constructed using the single-piece score-and-fold method with the V-ribs flattened as necessary. This piece was cut and scored as needed to fit snugly to the cable tray sides and bottom and was prebuttered with Thermo-Lag 330-1 trowel-grade material and secured to the tray with a 16-gauge stainless steel tie-wire. The top piece was cut to fit over the tray flush with the edges of the side pieces. The V-ribs were oriented perpendicularly to the cable tray side rails, and the ribs were flattened on the outer edges where they contacted the side rails of the cable tray and the mating edges of the ERFBS side pieces. The top panel was prebuttered with trowel-grade material where it mated with the top edges of the cable tray side rail and the ERFBS side piece edges. The top panel was then secured with stainless steel tie-wire. All joints and seams on the cable tray ERFBS assemblies were filled in with trowel-grade material, and the joints, where the vertical and horizontal fire barrier panels met, were laced together with stainless steel tie-wire on a 5-inch spacing. A skim-coat of trowel-grade material was applied to the cable tray enclosure, and an external layer of stainless stress skin was fitted to cover the entire assembly and stapled, as needed, to the ERFBS fire barrier baseline material. The stress skin, where it overlapped, was stitched together with stainless steel tie-wire on a 3-to-5-inch spacing. A final trowe--grade skim-coat was applied (approximately 1/16-inch layer) to the completed cable tray fire barrier enclosures. Once each cable tray ERFBS was completed and allowed to dry overnight, the final tie-wires were installed every 6 inches on center (maximum spacing) around each ERFBS.

Test Specimen 2 (3-inch conduit) was enclosed with 3/8-inch-thick Thermo-Lag 330-1 conduit preshapes except for approximately 3 feet of the vertical section above the radial bend. The internal surfaces of the first conduit preshape layer were prebuttered with trowel-grade material and secured to the conduit with stainless steel tie-wires. The preshaped sections installed on the radial bend were scored and bent to fit. The internal surfaces of these conduit preshapes were prebuttered with trowel-grade material and secured to the conduit radial bend with tie-wire. Once this layer had dried, a second 3/8-inch-thick Thermo-Lag 330-1 conduit preshape layer was installed by the same techniques used for the first layer. Once the second layer was completed, the radial bend area was coated with trowel-grade material and wrapped with external stress skin, which was secured in place with stainless steel tie-wires. A skim-coat of trowel-grade material was applied over the external stress skin. Once the assembly was completed and allowed to dry overnight, the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS test specimen.

The top 3 feet of the conduit were protected with 3M Corporation M20A fire barrier mat. This fire barrier mat was tightly wrapped around the conduit until five layers of this material were applied. All edges of the mat material were sealed with 3M fire mat tape. A collar approximately 6 inches wide and two layers thick was installed over the Thermo-Lag 330-1 to 3M interface joint with approximately 3 inches of 3M material overlapping the Thermo-Lag 330-1 conduit preshapes. Stainless steel tie-wires, spaced every 6 inches on center, were used to secure the M20A mat to the conduit.

Test Assembly 2-2 - Description

This test assembly consisted of a special tray fitting (double cable tray cross) connected to two 4-foot-long by 18-inch-wide standard weight steel ladder back cable trays with 4-inch side rails. The cable tray rungs were spaced 6 inches on center. The cable trays and the double-cross fitting were suspended 36 inches below the steel test deck. The double-cross fitting is an 18-inch-wide cable tray intersection where two parallel trays enter each side of this intersection. Steel angles (10 gauge) were cut to fit across the double-cross fitting and between the two parallel cable trays. A total of eight steel angles were installed on each side of the assembly. Three steel angles were uniformly spaced on each side of and across the double-cross fitting. These steel angles were located in the areas in which the ERFBS is seamed together. The steel angles were drilled to accommodate threaded steel rods that extended through the assembly. These steel rods held the steel angles in place, helped support the ERFBS panels, and kept them from sagging.

This ERFBS was a 1-hour assembly constructed from a single layer of nominal 5/8-inch-thick Thermo-Lag 330-1 panels. On the double-cross fitting and the cable trays, both the single-piece score-and-fold and individual-piece methods were used. All the fire barrier panel pieces were prebuttered with trowel-grade material where they mate with metal or other fire barrier panel surfaces. The top and bottom of the double-cross fitting were made out of four pieces of Thermo-Lag 330-1 fire barrier panel. These pieces and those on the 18-inch-wide cable trays were drilled to accommodate the threaded rods, and the individual fire barrier pieces were secured to the raceway with stainless steel tie-wires. Once the ERFBS panels were installed and secured in place, the joints and seams were filled with trowel-grade material, and an exterior layer of stress skin was fitted to cover the entire assembly and stapled in place to the baseline ERFBS as needed. At each seam of the double cross, a 6-inch-wide by 3/8-inch-thick flat Thermo-Lag 330-1 panel was installed. These panels were drilled to accommodate the threaded rods. A 1-1/2-inch-diameter flat washer and a nut were then applied to each threaded rod, and the nut was torqued down until the flat washer was snug with the surface of the ERFBS. The nuts and washers were covered with trowel-grade material. These trowel-grade mounds were covered with a 6-inch square patch of stress skin, which was a stapled in place to the baseline ERFBS material. The assembly was then completely skim-coated with trowel-grade material and, after it dried overnight, the final stainless steel tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS test specimen.

Test Assembly 2-3 - Description

This test specimen consisted of (1) three 18-inch-wide standard steel cable trays with 4-inch side rails and rungs spaced on 6-inch centers in a stacked configuration, (2) a single 18-inch-wide steel tray with a solid metal cover which had standoff extensions that raise the cover off the top cable tray rung flange by approximately 3 inches, (3) a 5-inch-diameter conduit-to-cable tray air drop, and (4) a 1-inch-diameter conduit-to-cable tray air drop.

In Test Specimen 1, the stacked 18-inch-wide cable trays were spaced approximately 12 inches apart. This configuration, a U-shape, extended down from the test deck into the furnace a maximum of 56 inches. This configuration made a maximum horizontal run of 108 inches. The cable trays in this stack configuration did not contain cables. The stacked cable tray ERFBS common enclosure was a 1-hour assembly constructed out of 5/8-inch-thick Thermo-Lag panels. This ERFBS specimen also tested the transition from a common enclosure to three individual cable tray fire barrier enclosures. The common ERFBS enclosure was constructed using the individual-piece method and the single-piece score-and-fold method. Before installation, all fire barrier panel pieces were prebuttered with trowel-grade material where they mated with the metal cable tray, its cover, and other fire barrier panel surfaces. Steel angles (10 gauge) were cut to fit between the stacked trays. Threaded steel rods were used to connect the parallel angles and to clamp them onto the cable tray side rails. The fire barrier panels were held in place with stainless steel tie-wires and threaded rods. These threaded rods were uniformally spaced and provided the method for retaining the vertical sides of the ERFBS box enclosure up against the stacked trays. Once the Thermo-Lag fire barrier material was installed, a layer of stainless steel stress skin was fitted over each individual cable tray and the common ERFBS enclosures, stitched together with stainless steel tie-wire, and stapled to the baseline ERFBS as necessary. A 1-1/2-inch-diameter flat washer and nut were installed on each threaded rod, and the nut was torqued down until the flat washer was snug against the surface of the fire barrier panels. The washers and nuts on the box enclosure were covered with trowel-grade material and secured in place with a 6-inch- square patch of stress skin stapled to the baseline fire barrier panels. The assembly was then completely skim-coated with trowel-grade material. Once the assembly was completed and allowed to dry overnight, the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

Test Specimen 2, a single 18-inch-wide steel tray with a solid metal tray cover, was located approximately 15 inches away from the stacked cable tray configuration. This tray was also configured in a U-shape, extended down into the furnace approximately 36 inches, and had a horizontal run of 96 inches. From the test deck, two air drops, Test Specimen 3, a 5-inch-diameter cable bundle, and Test Specimen 4, a 1-inch-diameter cable bundle, extended down from the deck and they transition into this tray. The 1-inch air drop transitioned into the radial bend and the 5-inch transitioned into the horizontal section of the cable tray. The cable tray had a 68-percent cable fill and weighed approximately 77 pounds per linear foot. Test Specimen 2, the 18-inch-wide tray with a solid metal raised tray cover, was protected by an ERFBS constructed from 5/8-inch-thick Thermo-Lag 330-1 panels. This ERFBS was fitted to the raceway using both the single-piece score-and-fold method and the individual-piece method. All fire barrier panel pieces were prebuttered with trowel-grade material where they mated with the metal cable tray, its cover, and other fire barrier panel surfaces. The fire barrier panels were secured in place to the raceway with stainless steel tie-wires, and the ERFBS joints were stitched together in certain locations. The two air drops feeding into this tray were enclosed with Thermo-Lag 330-1 conduit preshapes. The conduit preshapes on the 5-inch air drop had a baseline fire barrier constructed from 5/8-inch-thick Thermo-Lag 330-1 conduit preshapes. The ERFBS for the 1-inch air drop had a baseline fire barrier constructed from 5/8-inch-thick Thermo-Lag 330-1 conduit preshapes. This baseline was upgraded by enclosing it with a second 3/8-inch-thick conduit fire barrier preshape. Before its installation, the inner surface of the overlay fire barrier material was prebuttered with trowel-grade material. The assembly was held in place with stainless steel tie-wires, and all joints and seams of this overlay were prebuttered and filled with trowel-grade material. Once the Thermo-Lag panels on this cable tray assembly and air drops were secured in place, a layer of stress skin was fitted to cover the entire assembly, stapled to the ERSBS, as necessary, to hold it in place, and stitched together at the seams in certain locations. The assembly was then completely skim-coated with trowel-grade material. Once the assembly was completed and allowed to dry overnight, the final tie-wires were installed 6 inches on center.

The structural steel supporting the cable tray specimens was protected at its midspan with Thermo-Lag 330-1 for 18 inches from the point at which the support meets the ERFBS. The remainder of the support was protected with three layers of 3M M20A fire barrier mat material (from the Thermo-Lag interface point to the top of the test deck). At the Thermo-Lag 3M interface, the material overlapped the Thermo-Lag material for approximately 6-inches.

Test Assembly 2-4 - Description

This test assembly consisted of (1) group of eight 4-inch-diameter aluminum conduits (two columns of four conduits, (2) group of two 1-inch-diameter steel conduits (one column of two conduits), and (3) two seismic structural cable tray support members.

Test Specimen 1, a group of eight 4-inch-diameter aluminum conduits (two columns of four conduits) was installed near the front of the test deck. Spaced 7 inches apart both horizontally and vertically, these conduits passed through a rectangular blockout in the left concrete test deck wall, then transversed the entire length of the test deck, and exited through a large rectangular blockout in the right concrete test deck wall. These conduits had a 144-inch horizontal run through the furnace. All eight conduits were secured with steel conduit clamps attached to Unistrut supports anchored to the concrete test deck ceiling. A Unistrut fire barrier support structure (120 inches long by 33 inches wide by 33 inches deep) was constructed so as to enclose two sides of the eight grouped conduits. This structure was independent of and not in direct contact with the conduits and their supports. The fire barrier support structure was anchored to the front wall and the ceiling of the test slab, and had an annular space of approximately 7 inches between the fire barrier material and the conduits.

Test Specimen 2, a group of two 1-inch-diameter steel conduits (one column of two conduits), was installed near the rear of the test deck. Each of these conduits passed through blockouts in the right and left concrete test deck walls and had a 144-inch horizontal run through the furnace. A Unistrut fire barrier support structure was constructed to enclose two sides of these grouped conduits. This Unistrut fire barrier support structure was 120 inches long by 18 inches wide by 12 inches deep and was constructed like the one constructed for Test Specimen 1.

For Test Specimens 1 and 2, nominal 5/8-inch-thick Thermo-Lag 330-1 panels were used to construct the two-sided fire barrier enclosure. These Unistrut fire barrier support structures were L-shaped frames and were used to support the Thermo-Lag 330-1 fire barrier panels. The frames were anchored to the test deck side wall and the ceiling and had bolts welded on 12-inch centers along their horizontal and vertical frame to fire barrier panel mating surfaces.

The Thermo-Lag 330-1 fire barrier panels were cut to fit the frame and the ribs were flattened in the places where the panels contacted the frame. The frame and fire barrier panels were prebuttered with Thermo-Lag 330-1 trowel- grade material, and the panels were bolted to the frame.

Three types of butt joint designs were used to construct these conduit fire barrier enclosures: (1) butt joint between two fire barrier panels over the Unistrut fire barrier support structure frame members, (2) butt joint between two fire barrier panels with the joint in an open span between two frame members (backed with a 5/8-inch-thick by 6-inch-wide Thermo-Lag 330-1 panel on the inside of the enclosure), and (3) butt joint between two fire barrier panels with the joint in an open span between two frame members (backed with a 5/8-inch-thick by 6-inch-wide Thermo-Lag 330-1 panel on the outside of the enclosure). Where these joints were formed by backing the joint with a Thermo-Lag 330-1 panel on the inside of the enclosure, the backing panel was held in place with bolts, fender washers, and nuts. These bolts are in a parallel pattern with one on either side of the joint and spaced approximately 2 inches inward from the joint's edge and 4 inches away from each other. This bolt pattern is repeated every 12 inches along the entire length of the joint. On the fire barrier exterior, the joint was prebuttered with trowel-grade material, and stainless stress skin was installed over the joint. The stress skin was stapled in place and overlapped the joint on either side by 3 inches. For those joints where the backing panel was applied on the exterior of the fire panels, the backing panel was prebuttered and applied over the joint. The backing panel assembly was then covered by an external layer of stainless steel stress skin. The stress skin overlapped the edges of the backing panel by 2 inches and was stapled in place to the backing panel and the fire barrier panels.

Once the fire barrier material had been completely installed, the enclosure was skim-coated with trowel-grade material and, while still wet, covered with an external stress skin. The external stress skin was secured to the enclosure with 1/2-inch-long staples. The fender washers and nuts were installed on the frame studs where they penetrated the fire barrier material. The entire fire barrier enclosure was covered with a second skim-coat layer of trowel-grade material, and the nuts and fender washers were covered with a mound of trowel-grade material and covered with a 6-inch-square stress skin patch, which was secured to the fire barrier by staples. Each patch was then covered with a skim-coat of trowel-grade material. This ERFBS terminated approximately 24 inches away from where the conduits penetrate the test slab wall. The end of the two-sided fire barrier enclosure that terminated in the furnace was constructed out of individual fire barrier panel pieces (three pieces for Test Specimen 1 and two for Test Specimen 2) and cut to fit the contour of the conduits. The joints were backed on Test Specimen 1 with 5/8-inch-thick Thermo-Lag 330-1 panel on the inside of the enclosure. On the external side of the ERFBS, these joints were covered with stainless steel stress skin. The stress skin was secured to the fire barrier panels with staples. Once the end fire barrier panel pieces were installed, they were skim-coated with trowel-grade material, and external stress skin was installed on the end of the enclosure around the conduits. After the stress skin was installed, a second skim-coat layer of trowel-grade material was applied.

The conduits (eight 4-inch-diameter conduits) that exited the Test Specimen 1 ERFBS enclosure were protected with 5/8-inch-thick Thermo-Lag preshaped conduit sections. The conduits (two 1-inch-diameter conduits) that exited the Test Specimen 2 ERFBS enclosure were protected with a 5/8-inch-thick Thermo-

Lag 330-1 conduit preshape overlaid with a 3/8-inch-thick Thermo-Lag conduit preshape. All conduit surfaces and their fire barrier preshapes were prebuttered with trowel-grade material. The conduit preshapes were secured to the conduits with stainless steel tie-wire spaced 6 inches on center (maximum).

Test Specimen 3 consisted of two seismic structural steel cable tray support members. These members were constructed from 6-inch by 6-inch by 1/2-inch-thick wall steel tubing. These seismic supports formed trapeze-type hangers with three cross bars. The supports were 56 inches wide and 42 inches tall with 12-inch spacing between the cross bars. Installed on the cross bars of the support were 8-inch-long sections of 18-inch-wide steel ladder back cable trays. Support 1 had a single tray section attached to each cross bar with the tray section positioned in the center of the cross bar. Support 2 had one cable tray section position in the center of the top cross bar and two cable tray sections equally spaced on the middle and the bottom cross bars.

The two cable tray sections installed on the bottom cross bar of support 1 and the single cable tray section on the middle cross bar of support 2 were protected using the separate-piece method with 5/8-inch Thermo-Lag 330-1 panels. The tray section baseline fire barrier installations were then upgraded by applying a skim-coat of trowel-grade material and installing external stress skin. The external stress skin was stapled to the cable tray fire barrier enclosure. Once the stress skin was installed, a second skim-coat layer of trowel-grade material was applied. The remaining cable tray sections on the other cross members had no fire barrier protection.

The supports were protected with 5/8-inch-thick panels using the separate- piece method. The V-ribs were flattened on all panels, and these panels were prebuttered with trowel-grade material at their points of contact with the support steel and other panels. Once the fire barrier had been installed, the final stainless steel tie-wires were installed 6 inches on center (maximum).

Test Assembly 2-5 - Description

This test assembly consisted of (1) a 5-foot-wide by 3-foot-high by 2-foot- deep steel junction box (JB) fastened directly to the concrete test slab wall with anchor bolts, (2) A group of three parallel 3-inch-diameter aluminum conduits spaced 6 inches apart, (3) two parallel 1-inch-diameter steel conduits, and (4) a bank of aluminum conduits (five 2-inch-diameter conduits, a 2-1/2-inch-diameter conduit, and a 3-inch-diameter conduit).

The three parallel 3-inch-diameter aluminum conduits of Test Specimen 2 passed through a rectangular blockout in the test slab and entered an aluminum condulet LB that had its long side parallel to the test slab. These conduits extended vertically and parallel to the slab and at the end of their run they were capped with a coupling and a plug. The overall vertical run for each conduit was 36 inches. All three conduits were fastened to the test slab with a Unistrut support and the appropriate conduit clamps.

In Test Specimen 3, two parallel 1-inch-diameter steel conduits passed through a rectangular block out in the test slab and entered a malleable iron condulet LB that had its long side parallel to the test slab. These conduits extended vertically and parallel to the slab and at the end of their run were capped with a coupling and a plug. The overall vertical run for each 1-inch conduit was 96 inches. Both conduits were fastened to the test slab with a Unistrut support and the appropriate conduit clamps.

In Test Specimen 4, a bank of seven aluminum conduits passed through the test slab via a common rectangular blockout, and each conduit entered its respective aluminum condulet LB that had its long side parallel to the test slab. These conduits extended vertically and parallel to the slab and at the end of their run were capped with a coupling and a plug. The overall vertical run for each conduit in the bank was 96 inches. The conduits within the bank were spaced nominally 4 inches apart and fastened to the test slab with a Uni-strut support and the appropriate conduit clamps.

Two basic techniques were used to construct the three-sided Thermo-Lag 330-1 fire barrier configurations. The single-piece score-and-fold method was used to construct the baseline ERFBS on the three 3-inch-diameter aluminum conduits (Test Specimen 2) and on the two 1-inch steel conduits (Test Specimen 1). In this method of installation, a single 5/8-inch Thermo-Lag 330-1 preformed panel material was score-cut and folded to form the appropriately sized box enclosures. These boxes enclosed the conduits against the concrete test slab. The fire barrier panels were prebuttered with trowel-grade material on all interior surfaces which were in contact with the conduits and the concrete test slab. Thermo-Lag 330-1 trowel-grade material was used to square the corners along the folds.

The second method was the separate-board technique, which was used to construct the bank of seven conduits (Test Specimen 4). This baseline ERFBS was constructed of nominal 5/8-inch Thermo-Lag 330-1 preformed panel material cut to form the sides and top of the conduit box enclosure. The cuts were staggered and panels were installed internally, between the conduits, to provide additional support and keep the assembly square. The fire barrier material was prebuttered with trowel-grade material on all interior surfaces which were in contact with the conduits and the concrete test slab.

The JB was enclosed with Thermo-Lag 330-1 5/8-inch-thick fire barrier panels which had the ribs flattened. The separate-board method was used to construct this baseline ERFBS. All internal surfaces of the fire barrier panels were prebuttered with trowel-grade material before installation. The panels were secured to the junction box using 1/4-inch-diameter bolts, fender washers, and nuts.

Once all the baseline ERFBSs were constructed, they were upgraded by applying a skim-coat of trowel-grade material and external stress skin. The external stress skin was secured to the ERFBS enclosure with 1/2-inch-long staples, and a second skim-coat layer of trowel-grade material was applied over the external stress skin.

<u>Test Assembly 2-6 - Description</u>

This test assembly consisted of (1) eight 4-inch-diameter aluminum conduits banked in two sets of four, (2) one 60-inch by 12-inch by 12-inch pull box with a 4-inch-diameter conduit exiting the ends of the pull box, (3) four 3-inch-diameter steel conduits banked in sets of two, and (4) four 1-inch-diameter steel conduits banked in two sets of two. This assembly was tested in a wall furnace with the test specimens in a vertical orientation. Each test specimen was 10 feet high and was offset from the back concrete wall by 6 to 8 inches.

Each test specimen associated with this test deck was protected by a 1-hour upgraded Thermo-Lag 330-1 ERFBS. The fire barrier applied to Test Specimen 1 (eight 4-inch-diameter conduit configurations) was constructed using 5/8-inch-thick Thermo-Lag 330-1 panels and conduit preshapes. The conduit preshapes were cut down the center to form 90° sections. These sections were prebuttered on their inner surface with trowel-grade material and then used to form the outside corners of the conduit bank ERFBS enclosure. The sides of the fire barrier enclosure was formed of Thermo-Lag 330-1 fire barrier panels cut to fit between the conduit preshapes. These individual fire barrier panel pieces were prebuttered on their interior surfaces with trowel-grade material before being installed up against the conduits. All joints and seams of the fire barrier assembly were prebuttered and filled with trowel-grade material. Fire barrier panels that were wider than 36 inches were held in place with threaded steel rods. These steel rods were installed through the assembly to support the fire barrier panels and keep them up against the conduits. A 1-1/2-inch-diameter flat washer and a nut were applied to each threaded rod, and the nut was torqued down until the flat washer was snug with the surface of the panels. The steel rods were spaced approximately every 18 inches on center along the length of the enclosure. In addition, at fire barrier panel joints on panels wider than 36 inches, a backing board (6 inches wide by 5/8 inch thick by length of joint) was installed. Bolts, fender washers, and nuts were used to hold the joint backing board in place and to secure the panel sections together. Once the fire barrier material was installed on the conduit bank assembly, a layer of stress skin was fitted, stapled, and stitched together in certain locations to cover the entire assembly. The washers and nuts on the box enclosure were then covered with trowel-grade material and secured in place with a 6-inch-square patch of stress skin, which was stapled in place to the ERFBS baseline material. The assembly was then completely skim-coated with trowel-grade material and allowed to dry overnight. Once the ERFBS had dried, the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

The ERFBS installed on Test Specimen 2 (conduit pull box) was constructed from 5/8-inch thick Thermo-Lag fire barrier panels and conduit preshapes. The Thermo-Lag 330-1 panels were cut to fit the pull box, and conduit preshapes were used to construct the ERFBS for the conduits that exit the ends of the pull box. The internal surfaces of the fire barrier panels and the conduit preshapes where they mate with the pull box and the conduit surfaces and their adjoining joints and seams were prebuttered with trowel-grade material. The fire barrier material was then installed onto the raceway and secured in place with stainless steel tie-wires. Once the baseline ERFBS was installed, a layer of stress skin was fitted to cover the entire conduit pull box assembly, stapled in place to the ERFBS baseline material, and stitched together in certain locations. The entire conduit and pull box test specimen was then completely skim-coated with trowel-grade material and allowed to dry overnight, and the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

The fire barrier being installed on Test Specimen 3 (four 3-nch-diameter conduits) was constructed of 5/8-inch-thick Thermo-Lag 330-1 fire barrier panels. This conduit ERFBS enclosure was constructed by the single-piece score-and-fold method. The joints and seams were prebuttered with trowel-grade material. In addition, the fire barrier panels will be prebuttered with trowel-grade material to the conduits. The fire barrier panels were secured in place with stainless steel tie-wires. Once the fire barrier panels were secured in place, a layer of stress skin was fitted to cover the entire assembly, stapled in place to the ERFBS baseline material, and stitched together in certain locations. The assembly was then completely skim-coated with trowel-grade material and allowed to dry overnight. Once the ERFBS had dried, the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

Test Specimen 4 (bank of four 1-inch-diameter conduits) had a fire barrier enclosure applied to it that was constructed from individual 5/8-inch-thick Thermo-Lag 330-1 panels. The joints and seams of the fire barrier panel pieces and the internal surfaces where they mate with the conduits were prebuttered with trowel-grade material. The fire barrier material was secured in place with stainless steel tie-wires and a layer of stress skin was fitted to cover the entire assembly, stapled in place to the ERFBS baseline material and stitched together in certain locations. Upon completing the installation of the stress skin upgrade, the assembly was completely skim-coated with trowel-grade material. Once the installation was completed, the ERFBS was allowed to dry overnight and the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

Two types of fire barrier base plates (used to terminate ERFBS at a concrete wall, floor, or ceiling) were tested as part of this test assembly. The Type A base plates were installed after the ERFBS had been installed, and Type B base plates were installed before the ERFBS was installed. Both base plate designs were constructed from 5/8-inch-thick Thermo-Lag 330-1 panels, and were prebuttered with trowel-grade material, and fastened to the concrete with concrete anchors spaced 12 inches on center.

<u>Test Assembly 2-7 - Description</u>

This test assembly consisted of (1) seven parallel 4-inch steel conduits spaced approximately 1-1/2 inches apart, (2) one 3/4-inch aluminum conduit, and (3) a 3/4-inch steel conduit. The seven parallel conduits were configured in a U-shape. These seven parallel conduits extended down from the test deck approximately 36 inches, made a 90° turn through a lateral bend (LB) condulet, ran horizontally approximately 108 inches, and made a 90° turn through radial conduit bends back up through the test deck. The 3/4-inch aluminum and steel conduits were arranged in two separate U-shape configurations and incorporated a 90° LB and a 90° radial bend. These conduits extend down from the test deck 36 inches and have a horizontal run of approximately 48 inches.

The ERFBS enclosure for the seven parallel 4-inch conduits was constructed from 5/8-inch-thick Thermo-Lag 330-1 panels and conduit preshapes. The horizontal run and the vertical span created by the parallel plane of these conduits were enclosed with individual fire barrier panels. The outer edges of the conduits were enclosed using Thermo-Lag conduit preshapes. The inner surfaces and adjoining edges of the conduit preshapes and panel pieces were prebuttered with trowel-grade material and secured to the raceway with stainless steel tie-wires. In addition, threaded steel rods were used to secure the Thermo-Lag top and bottom panels to the parallel conduit bank. The threaded rod sets, consisting of two rods spaced approximately 20 inches apart, were distributed along the length of the assembly at 18-inch intervals.

Each rod was located approximately 10 inches away from the outer edges of the conduit bank. The radial conduit bends on the parallel conduits were enclosed using Thermo-Lag 330-1 panels. On the inside and outside of the radial bend these panels were fitted by using the single-piece score-and-fold method. The outer ends of this assembly were fitted with flat panels. All joints and seams and mating surfaces of the radial bend fire barrier segment were prebuttered with trowel-grade material before installation. Where this segment terminated just above the radial bend, the seven parallel conduits extending vertically up through the test deck were protected individually with Thermo-Lag 330-1 5/8-inch-thick conduit preshapes.

At the opposite end of this test specimen, the seven parallel conduits transition from horizontal to vertical through LBs that made a 90° turn. A common box fire barrier enclosure was constructed for the LBs. Where the LB fire barrier enclosure segment ended, the conduits were protected using the same Thermo-Lag panel/conduit preshape technique used on the horizontal run. Once the fire barrier was completely installed, a layer of stress skin was fitted to cover the entire assembly and stapled in place to the ERFBS baseline material. The ERFBS was completely skim-coated with trowel-grade material and allowed to dry overnight, and the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS test specimen.

The ERFBSs for both the steel and the aluminum 3/4-inch LBs were constructed by the single-piece score-and-fold method from Thermo-Lag 330-1 V-ribbed, 5/8-inch-thick panel. The internal surfaces of these ERFBS boxes were prebuttered with trowel-grade material and held in place with tie-wire until the trowel-grade material dried. After the baseline material was installed, an overlay of a 3/8-inch-thick fire barrier panel was applied using the single-piece method.

Both the steel and the aluminum 3/4-inch conduits were protected by 5/8 inch thick conduit preshapes and overlaid with a 3/8-inch-thick Thermo-Lag 330-1 fire barrier conduit preshape. The interior surfaces and edges of the conduit preshape fire barrier material were prebuttered with trowel grade material. The fire barrier assembly was held in place with stainless steel tie-wires. The same installation techniques were used for the radial bend section, except that an additional external stainless steel stress skin layer was installed in the radial bend area.

Once the installation of these ERFBSs had been completed, these assemblies were completely skim-coated with trowel-grade material, allowed to dry overnight, and the final tie-wires were installed every 6 inches on center (maximum spacing) around the ERFBS.

3.7.6.3 Phase 3 - Cable Tray, Conduit, and Junction Box 3-Hour Fire Barrier Test Program

<u>Test Assembly 3-1 - Description</u>

This test assembly consisted of (1) a 24-inch-wide steel cable tray, (2) a 12- inch-wide steel cable tray, and (3) a 12-inch-high by 12-inch-wide by 60-inch- long steel JB. The cable trays were assembled in an L-shaped configuration with each vertical leg transitioning 36 inches down from the upper test deck into a zero-radius 90° bend (formed by adjustable splice plates) and extending horizontally 70 inches out through the front furnace wall. Both cable trays were supported in position by a single "trapeze"-type hanger constructed from 3-inch steel channels bolted and welded together. The JB was supported from the test deck by two "trapeze"-type hangers from 3-inch steel channels.

The application of these ERFBS is divided into four distinct installation steps: (1) installation of Thermo-Lag 330-1 baseline fire barrier material, (2) reinforcement of the baseline fire barrier system, (3) installation of the Thermo-Lag 770-1 mat upgrade, and (4) trowel-grade skim-coat finish.

The "baseline" ERFBS application was constructed using Thermo-Lag 330-1 materials. The design of this baseline fire barrier used a "worst-case" design which represented the least desirable attributes. For example, all the joints between the Thermo-Lag 330-1 panels were post-buttered and the fire barrier panel V-ribs were installed parallel to the cable tray side rails. The baseline ERFBS application on the cable trays used the separate-piece method. This fire barrier was constructed from nominal 1-1/4-inch-thick Thermo-Lag 330-1 V-ribbed panels. The fire barrier panels were dry fit to the cable trays and banded to hold them in place. The top and bottom fire barrier panels had the V-ribs running parallel to the cable tray side rails and the side panels had the V-ribs perpendicular to the side rails. Once the baseline ERFBS was installed on the cable trays, the baseline fire barrier material was installed on the cable tray hanger/support. The fire barrier enclosure for the cable tray support was constructed using separate 1-1/4-inch Thermo-Lag 330-1 panels dry fitted and banded to the support steel. The band spacing for the cable trays and their common support was 12 inches maximum with bands installed within 2 inches of joints. The JB ERFBS was constructed using the same techniques as for the cable trays.

Once the baseline fire barrier system had been installed, the baseline system was reinforced with a layer of external stress skin. A liberal layer of Thermo-Lag 770-1 trowel-grade material was applied to the baseline fire barrier system before the installation of the external skin and then stapled to the baseline while the trowel-grade material was still wet. The trowel-grade material was smoothed and allowed to dry overnight. Once the assembly had dried, stainless steel tie-wires were added (maximum spacing 6 inches).

To begin the Thermo-Lag 770-1 upgrade, the cable tray 90° bend was covered with the mat first. Before its installation, the Thermo-Lag 770-1 trowel-grade material was applied to baseline fire barrier system in the area of the 90° bend and the inside surface of the fire barrier mat. The mat material was then installed and stapled to the baseline material with 1-inch-long staples. Once the 90° fire barrier material had been installed, the fire barrier mat was installed on the vertical and horizontal tray sections. A liberal coat of Thermo-Lag 770-1 trowel-grade material was applied to the baseline fire barrier system and to the inner surface of the fire barrier mat. The fire barrier mat was installed around the tray with at least a 3-inch overlap. Staples were used as necessary to ensure the mat was in contact with the baseline material. The joints between mats were butted together and a minimum 6-inch-wide wrap of Thermo-Lag 75 High Temperature Fabric Reinforcement was applied over the joint. Tie-wires were then installed with a maximum spacing of 6 inches. Once the first layer was completed, the second layer of Thermo-Lag 770-1 mat was installed using the same installation techniques and design attributes. All the overlaps and material seams were staggered between the layers.

The same basic two-layer Thermo-Lag 770-1 fire barrier system using the same installation techniques and design attributes utilized on the cable trays was applied to the JB and its supports and to the cable tray supports.

Upon completion of the Thermo-Lag 770-1 fire barrier mat installations, the assembly was then skim-coated with trowel-grade material.

Test Assembly 3-2 - Description

This test assembly consisted of (1) a 24-inch-wide steel cable tray, (2) a 12- inch-wide steel cable tray, (3) a 5-inch-diameter steel conduit with LB, (4) a 2 steel conduit with LB, (5) a 1-inch-diameter steel conduit, and (6) 2-inch-diameter air drop. The cable trays were assembled in an L-shaped configuration with each vertical leg transitioning 36 inches down from the upper test deck into a zero-radius 90° bend (formed by adjustable splice plates) and extending horizontally 70 inches out through the front furnace wall. An air drop transitioned from a 2-inch steel conduit passing through the upper test deck into the left side of the 24-inch-wide cable tray. The conduits were assembled in an L-shaped configuration with the individual 36- inch vertical conduit runs transitioning into LB and extending 70 inches horizontally through the front furnace wall. Both cable trays and conduits were supported in position by a common "trapeze"- type hanger constructed from 3-inch steel channels and Unistrut bolted and welded together.

The ERFBS applied to the 12- and 24-inch-wide cable trays utilized the baseline Thermo-Lag 330-1 fire barrier design with a Thermo-Lag 770-1 fire barrier upgrade. The design attributes and the installation techniques used to construct this ERFBS and the fire barriers for the cable tray and conduit supports were the same as those used to construct the ERFBS for the cable tray and support test specimens tested as part of Test Assembly 3-1.

The conduits were dry fitted and banded with nominal 1-1/4-inch-thick Thermo-Lag 330-1 conduit preshapes. The stainless steel bands were spaced every 12 inches (maximum spacing) and installed within 2 inches of a joint. The LBs were constructed by the separate-piece method. The baseline ERFBS was constructed from Thermo-Lag 330-1 V-ribbed 1-1/4-inch-thick panels, and small finishing nails were used to hold the pieces together during assembly. The LBs were installed after the conduit ERFBS and overlapped the conduit fire barrier material. After the installation of the baseline fire barrier material, the entire assembly was post-buttered with Thermo-Lag trowel-grade material.

The baseline Thermo-Lag 330-1 fire barrier system for the 2-inch air drop was constructed by dry fitting and banding conduit preshape material together and post-buttering the assembly with Thermo-Lag trowel-grade material together.

The baseline ERFBS installed on the LBs and the air drop was reinforced by covering its surface with external stainless steel stress skin. Before installing the stress skin reinforcement, a liberal coating of Thermo-Lag 770-1 trowel-grade material was applied to the LB. The external stress skin was stapled to the baseline material while the trowel-grade material was still wet. Once the stress skin was installed, a second coat of trowel-grade material was applied to cover the stress skin. The assembly was allowed to dry and stainless steel tie-wires were then installed with a maximum spacing of 6 inches.

The Thermo-Lag 770-1 mat upgrade was installed on the conduit LBs first. Before installing the mat on the LB, the inner surface of the mat and external surface of the baseline fire barrier material were coated with Thermo-Lag 770-1 trowel-grade material. The mat was held in place by stapling it to the baseline fire barrier material. On the conduits, the Thermo-Lag 770-1 mat was wrapped around the conduit and had an overlapping seam. The inner surface of the mat and the external surface of the conduit baseline fire barrier material were prebuttered with Thermo-Lag 770-1 trowel-grade material. Two layers of mat material were installed on the 2-inch and 5-inch-diameter conduits and their associated LBs, and three layers were applied to the 1-inch-diameter conduit and its LB. The additional layers of mat were installed in the same manner as the first layer and the seams and overlaps of these layers were appropriately staggered. Once the installation of the mat was completed, tie-wires were then installed on the assembly with a maximum spacing of 6 inches. The air drop and cable tray upgrades are interrelated. The air drop upgrade consisted of applying a total of three layers of Thermo-Lag 770-1 mat to the baseline fire barrier material. The Thermo-Lag 770-1 fire barrier material was always installed on the air drop first and then on the cable tray for each layer. This material overlapping formed an interlock between the layers. The general method of material installation and application of trowel-grade material and tie-wires was the same as that used for upgrading the baseline conduit ERFBS.

Upon completion of the Thermo-Lag 770-1 fire barrier mat installations, the assembly was then skim-coated with trowel-grade material.

3.7.7 Fire Endurance Test Results

The results of the applicant's Phase 1 (1-hour fire tests of conduit and junction boxes), Phase 2 (1-hour fire tests of cable tray and unique configurations), and Phase 3, (3-hour fire tests of cable tray, conduit and junction boxes) electrical raceway fire barrier system testing program are summarized at the end of this safety evaluation in Tables 1, 2, and 3, respectively. Each test assembly was subjected to an ASTM E-119 standard fire for 1 hour and a hose stream (fog) test as described in Section 3.7.4.

3.7.8 Conclusion - Electrical Raceway Fire Barrier Systems

On the basis of the applicant's Thermo-Lag Phase 1, 2, and 3 fire endurance test programs, the staff concludes that the fire barrier applications presented in Tables 4 and 5 (at the end of this safety evaluation) met the fire test acceptance criterion and provide the required fire-resistive rating and, therefore, are acceptable.

3.7.9 Fire Barrier Deviations and Special Configurations

The applicant's Thermo-Lag fire endurance testing program established the technical and installation attributes for most of the ERFBS configurations being installed at Watts Bar. The applicant found approximately 346 cases in which the application of Thermo-Lag fire barrier materials used to protect electrical raceways and their structural steel supports deviated from the tested configurations. In Generic Letter 86-10, "Implementation of Fire Protection Requirements," April 24, 1986, NRC provided its guidance on what should be considered when performing an engineering evaluation of a deviating in-plant fire barrier condition. The applicant, in its engineering evaluations of these conditions, used this guidance to establish the fire barrier evaluation criteria, summarized below:

(1) The continuity of the fire barrier material applied was consistent with the tested configuration.

(2) The effective thickness of the fire barrier material applied to the unique configuration was consistent with the thickness of the fire barrier material tested.

(3) The nature and effectiveness of the fire barrier support assembly were consistent with the tested configurations.

(4) The application and end use of the fire barrier material were consistent with the tested configuration.

The applicant has performed engineering evaluations for the following deviating fire barrier conditions: minor ERFBS configuration variations, minor ERFBS deviations, unique ERFBS configurations, ERFBS intervening item protection variations, and ERFBS support protection variations. The inspectors audited 30 deviating ERFBS configurations to determine if they were engineered, designed, and constructed using the same basic application techniques and construction attributes qualified in the applicant's Thermo-Lag fire endurance test program. The rest of Section 3.7.9 summarizes the staff's audit of significant deviating Thermo-Lag fire barrier configurations.

Minor ERFBS Configuration Variations

Configuration 1: DCN F36027A - The flex connector protection was located close to the support strap oversize conduit section at support D1207042-2-A47056-205; therefore, the conduit section could not be lapped 1 inch over the conduit protection as required by Drawing 47W243. The applicant's fire endurance test program demonstrated the ability of two layers of 3/8-inch-thick preformed Thermo-Lag 330-1 conduit sections to protect a 3-inch-diameter conduit. The design for this fire barrier interface between the oversized protection at the support strap assembly and the oversized coverage for the flexible connector provided the essential fire barrier attributes of the tested configuration. Therefore, the staff found reasonable assurance that this plant-specific fire barrier variation had a minimum 1-hour fire resistance.

Configuration 2: DCN F37025A - Large base plates were located close to the M-board interface; therefore, cable tray fire barrier protection could not be installed at the interface as required by Drawing 47W243-23, Detail C-23. Thermo-Lag shims were installed to bring the cable tray coverage out to abut the corners of the adjacent baseplates. The shims were secured by two tie-wires. The cable tray fire barrier, external stress skin, and the border of the tray were notched at the baseplate. All gaps were filled with Thermo-Lag trowel-grade material. The external stress skin and putty balls were installed over the M-board/Thermo-Lag fasteners. The design for this interface between the cable tray and the baseplate maintained the continuity of the fire barrier application and fire barrier material thickness to that which was tested by the applicant's test program. Therefore, the staff found reasonable assurance that this plant-specific fire barrier variation retained a minimum 1-hour fire resistance.

Minor ERFBS Deviations

Configuration 3: DCN F35139A - The first layer of Thermo-Lag protection on conduit 2PLC590B (1-1/2-inch diameter) was installed close to fire protection pipe support H491-28-41-7; therefore, the required second layer of Thermo-Lag cannot be installed without protecting the support as an intervening item. At the interface of conduit 2PLC590B and the fire protection support, the second layer of 3/8-inch-thick preformed conduit section was prenotched to accommodate the upper and lower sections of the support. All interface points were prebuttered with Thermo-Lag trowel-grade material. A third layer of 3/8-inch-thick preformed Thermo-Lag conduit section was notched and butted up to the support interface and extends at least 2 inches beyond the areas of interference. The design for this fire barrier interface between the conduit and the pipe support maintained its continuity and increased the thickness of the fire barrier material at the point of interface over that which was typically tested in the applicant's test program. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

Configuration 4: DCN F37087A - The close proximity of cable tray 3B21902191 to its support prevented the additional circumferential external stress skin from being installed around and over air drop collar as required by Drawing 47W243. The Thermo-Lag panel air drop collar (5/8-inch thick) was installed over the previously installed cable tray circumferential stress skin. An additional layer of external stress skin was installed over the Thermo-Lag collar panel. This stress skin extended vertically (up and down) 6 inches onto the cable tray coverage and 3 inches onto the side rail coverage. This external stress skin was secured in place with tie-wires that were bridled off from the circumferential tie-wires. The maximum wire spacing of 6 inches was maintained. The applicant tested typical cable tray and air drop interfaces in its fire endurance test program and, to construct this deviating assembly, used the construction attributes proven by the test configuration. In addition, this interface design between the air drop and the cable tray/support interference maintained the required continuity of the fire barrier application and the required fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

Unique ERFBS Configurations

Configuration 6: DCN F33862A - Security bars were located near nonessential conduits 2PLC4044B and 2PLC4045B and essential conduit 1PLC593S; therefore, Thermo-Lag fire barrier material could not be installed on these conduits as required by Drawing 47W243. The fire barrier enclosure for this unique design was a six-sided box constructed with nominal 5/8-inch-thick Thermo-Lag 330-1 panels. The dimensions of this enclosure were 22 inches by 18 inches by 60 inches. The enclosure was constructed using the separate-piece score-and-fold installation methods. Two of the side panels of the box enclosure had to be notched and fitted around tube steel supports. The top and bottom panels were stitched with tie-wire on both sides of the conduit and enclosed the support tube steel within the box. The conduit collars at the box conduit interface were constructed with preformed Thermo-Lag conduit sections or flat panels using the score-and-fold/roll method and were secured in place at the interface with tie-wires. The side panels of the box enclosure were secured in place with all-thread rods spaced 12 inches on center. All joints, seams, and interface points were prebuttered, and voids were filled with Thermo-Lag trowel-grade material. The assembly was covered with external stress skin and skim-coated. Variations typical of box enclosures and their methods of attachment to the raceway were tested in the applicant's fire endurance test program, and the construction attributes proven by these tested configurations were used to construct this unique fire barrier assembly. In addition, this design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

<u>Configuration 7:</u> DCN F34517A - Essential cable tray 5B1532154 was located near the ceiling; therefore, the top panel of the fire barrier could not be installed as depicted in Drawing 47W27314, Detail C4 or D4. The cable tray box enclosure was attached directly to the ceiling because the tray was located close to the ceiling. The box enclosure was constructed of 5/8-inch-thick Thermo-Lag panels. The bottom panels were stitched to the side panels with tie-wire on 6-inch centers. In addition, the bottom panels were supported by two sets of tie-wires wrapped around the cable tray through predrilled holes. One set of tie-wires was installed before the stress skin was installed and the other was installed after the stress skin has been applied. The tie-wires were on 6-inch centers. The panels that formed the ends of this enclosure were secured in place to the side panels with tie-wire stitches. Variations of typical box enclosures and their methods of attachment to raceway and concrete slabs were tested in the applicant's fire endurance test program, and the construction attributes proven by these tested configurations were used to construct this unique fire barrier assembly. In addition, this design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

<u>Configuration 8:</u> DCN No F34559A - A lateral bend (LB)(4-inch by 19-1/2-inch by 6-1/2-inch) on essential 3-inch-diameter conduit 1PLC3949B was located near essential 4-inch-diameter conduit 1PLC3803B; therefore, the essential LB could not be protected as required by Drawing 47W243-2, Detail A2. Shim panels of 5/8-inch Thermo-Lag 330-1 material were installed on both sides of the LB and were secured in place with tie-wire. These panels extended from the wall to the top of the LB fitting. A box assembly was then installed around the LB condulet and essential flexible conduits 1PLC3803B and 1PLC3804B. The box assembly was constructed using the single-piece method, and the joints and seams were stitched together. The external stress skin for all panels covering the vertical portion of the LB extended over the top piece and lapped on to the conduit a minimum of 2 inches. The essential flexible conduits were protected with Thermo-Lag and abutted the box assembly. The external stress skin on the essential conduits extended on to the box assembly a minimum of 6 inches. The border panels were attached to the wall, and external stress skin overlapped the interface joint and extended a minimum of 6 inches onto the box. This interface joint was stitched together on 6-inch centers. Variations of typical box enclosures and their methods of attachment to raceway and concrete slabs were tested in the applicant's fire endurance test program, and the construction attributes proven by these tested configurations

were used to construct this unique fire barrier assembly. This design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

Configuration 9: DCN F36295A - Pull Box 2-PB-292-588-03 (47-1/2 inches high by 47-1/2 inches wide by 12 inches deep) was protected with Thermo-Lag 330-1. The pull box was covered with 5/8-inch-thick Thermo-Lag flat panels. The tube steel and Unistrut supports for the pull box were covered with 5/8-inch-thick Thermo-Lag flat panels. Mounting bolts were used to attach the Thermo-Lag panels to the pull box. These panel-mounting bolts were installed on 12-inch centers. A complete external stress skin wrap was applied to the entire essential box configuration. This stress skin was lapped onto the adjacent support and onto the Thermo-Lag portion of the adjacent nonessential pull box. Variations of typical box enclosures, including their methods of attachment to junction and pull boxes and concrete slabs, were tested in the applicant's fire endurance test program, and the construction attributes proven by these tested configurations were used to construct this unique fire barrier assembly. This pull box fire barrier design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

Configuration 10: DCN F37282A - The in-plant configuration prohibited the installation of individual protection on the EYE fittings installed at the wall. In addition, space limitations associated with the ground clamps prohibited the EYE fittings for essential flexible conduit 1NM3371D and intervening flexible conduit 1NM3370D from being enclosed in a 3/8-inch plus 3/8-inch enclosure. The EYE fittings were enclosed in a common box. This box design had 5/8-inch-thick Thermo-Lag flat panels. Shims were installed at the bottom of the EYE fittings to extend the bottom of the box enclosure below the ground clamps. The two flexible conduits were protected with a two-layer design. The first Thermo-Lag conduit preformed layer was 5/8-inch thick, and the second layer was 3/8-inch thick. The conduits and the box enclosure were enclosed with external stress skin and a layer of Thermo-Lag trowel-grade material. The border of the box and the interior stress skin overlap were anchored to the wall, and the external stress skin covering the box was stapled to the Thermo-Lag border. Variations of typical box enclosures, including methods of attachment to LB fittings and concrete slabs, were tested in the applicant's fire endurance test program, and the construction attributes proven by these tested configurations were used to construct this unique fire barrier assembly. This pull box fire barrier design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

ERFBS Intervening Item Protection Variations

Configuration 11: DCN F35139A - A tube steel member was in contact with essential conduit 2PLC590B causing the sheet metal wall to be a secondary interference. Essential conduit 2PLC590B was protected in accordance with the approved methods qualified in the applicant's Thermo-Lag fire endurance test program. The top plate and the horizontal tube steel support for the sheet metal wall were protected with 5/8-inch-thick Thermo-Lag panels for 18 inches in all directions from the interfacing essential conduit. Some 3/8-inch shims were installed around the sheet metal wall fasteners to create a level surface. The sheet metal wall was protected with 5/8-inch Thermo-Lag fire barrier panel for 9 inches away from the penetrating essential conduit on both sides of the wall. Through-bolt and all-thread fasteners were used to attach the Thermo-Lag panels to the sheet metal wall, and tie-wire stitching was used to secure a butt joint between the panel pieces on opposite side of the wall from the tube steel support. Variations of typical structural steel raceway supports were tested in the applicant's Thermo-Lag fire endurance test program. This test program established the technical basis for protecting a minimum of 18 inches for structural steel supports and other intervening or interfacing items that were in direct contact with the protected raceway and the technical basis for protecting 9 inches of a commodity that interferes with the raceway's fire barrier system but does not come in direct contact with the essential raceway. This deviating fire barrier condition was constructed using attributes proven by the applicant's test program, and these same basic attributes were used to construct this unique fire barrier for an intervening item. This support/sheet metal wall interference fire barrier design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that a minimum 1-hour fire resistance was provided for this plant-specific fire barrier deviation.

<u>Configuration 12:</u> DCN F37025 - Nonessential air drop LTB1862 was located near essential cable tray 3B20452046; therefore, the required intervening protection will extend down onto the unsupported air drop. The preformed Thermo-Lag conduit sections were extended beyond the ends of the nonessential conduit (intervening item with essential cable tray 3B20452046) approximately 1-1/4 inches. Two 5/8-inch panels were trimmed to fit around the air drop cables and to fit snugly up into the conduit preformed ends where the air drop cables enter the conduit. External stress skin was installed over the end panels and extending back onto the conduit protection a minimum of 2 inches. This conduit/air drop interference fire barrier design maintained the required continuity of the fire barrier application and the fire barrier material thickness. Therefore, the staff found reasonable assurance that this plant-specific fire barrier deviation retained a minimum 1-hour fire resistance.

On the basis of it's review of these deviating Thermo-Lag fire barrier configurations, the staff concluded that the applicant adequately demonstrated that (1) the continuity of the fire barrier material applied was consistent with the tested configuration, (2) the effective thickness of the fire barrier material applied to the unique configuration was consistent with the thickness of the fire barrier material tested, (3) the nature and effectiveness of the fire barrier support assembly was consistent with the tested configurations, and (4) the application and end use of the fire barrier material were consistent with the tested configuration. Therefore, the applicant's program for evaluating deviating fire barrier conditions should provide reasonable assurance that these conditions will not significantly affect the fire resistive performance of the installed raceway fire barrier system and, therefore, is acceptable.

3.7.10 Ampacity, Derating Tests, and the Application of Test Results

The applicant conducted extensive ampacity derating testing of various Thermo-Lag fire barrier configurations at the applicant's Central Laboratories Services Department (CLSD) (denoted "Phase I tests") in Chattanooga, Tennessee, from March 9 to April 6, 1993; April 30 to May 10, 1993; and June 1 to June 22, 1993; and at Omega Point Laboratories (OPL) (denoted "Phase II tests") in San Antonio, Texas, from August 16 to 26, 1994; September 14 to October 6, 1994; November 15 to December 3, 1994; and January 4 to 23, 1995. The applicant submitted the results of its Thermo-Lag 330-1 Phase I and II ampacity tests to the staff on July 9, 1993, and April 25, 1995, respectively. Finally, a new Thermo-Lag fire barrier material, Thermo-Lag 770-1, for a 3-hour fire-rated electrical raceway application will be submitted for staff review at a later date. Given that no deviations were identified that required cable functionality verification, this evaluation pertains to ampacity-related issues only.

The applicant has committed to submit the results of all of the required ampacity derating tests as they become available. The following interim evaluation reviews the technical basis of the ampacity derating factors for Watts Bar Unit 1 until the applicant can complete all of the ampacity derating tests and analysis. The applicant's ampacity derating test methodology conformed to the guidance in draft Institute of Electrical and Electronics Engineers (IEEE) Standard P848, "Procedure for the Determination of the Ampacity Derating of Fire Protected Cables," Revisions 11, 12, and 14, dated April 6, 1992; February 24, 1993; and April 15, 1994, respectively, except for changes identified in individual test plans. After the applicant issued the test report "Testing To Determine Ampacity Derating Factors for Fire Protected Cables for Watts Bar Nuclear Plant" (Phase 1 tests), with its submittal of July 9, 1993, the staff documented its concerns in its request for additional information (RAI), which the NRC staff gave to applicant representatives in a meeting on October 13, 1993. The staff also identified concerns documented in its RAI dated May 5, 1993, before the start of testing. A meeting between applicant representatives and NRC staff was also held on August 30, 1994 (summary by L. Dudes, dated September 15, 1994). The applicant responded to the staff's questions regarding Watts Bar by letters dated Jone 30, 1993; November 26, 1993; and December 23, 1994.

General Design Criterion (GDC) 17 requires that onsite electric power systems be provided to permit the functioning of structures, systems, and components important to safety. The onsite electric power system must have sufficient capacity and capability to ensure that vital functions are maintained. IEEE Standard 279, "Criteria for Protection Systems for Nuclear Power Generating Stations," and IEEE Standard 603, "Criteria for Safety Systems for Nuclear Power Generating Stations," contain guidance on acceptable methods of complying with GDC 17 and the single-failure criterion. These IEEE standards state that the quality of protection system components and the onsite power system shall be achieved by specifying requirements known to promote high quality, such as the requirements for the derating of components, and that the quality shall be consistent with minimum maintenance requirements and low failure rates. Furthermore, IEEE Standards 279 and 603 state that test data or reasonable engineering extrapolation based on test data shall be made available to verify that protection system equipment continually conforms to the performance requirements determined to be necessary for achieving the system requirements.

In Regulatory Guide (RG) 1.75, "Physical Independence of Electric Systems," the NRC staff gave guidance for complying with IEEE Standard 279 and GDC 17 for the physical independence of the circuits and electric equipment comprising or associated with the Class 1E power system. The applicant uses Thermo-Lag 330-1 barriers to achieve physical independence of Class 1E electrical systems in accordance with RG 1.75. The staff's concerns about ampacity derating apply to Thermo-Lag 330-1 barriers installed to achieve physical independence of electric systems and to those installed to protect the safe-shutdown capability from fire.

Cables enclosed in electrical raceways protected with fire barrier materials are derated because of the insulating effect of the fire barrier material. Other factors that affect ampacity derating include cable fill, cable loading, cable type, raceway construction, and ambient temperature. The National Electrical Code, Insulated Cable Engineers Association (ICEA) publications, and other industry standards provide general ampacity derating factors for open air installations but do not include derating factors for fire barrier systems. Although a national standard ampacity derating test method has not been established, ampacity derating factors for raceways enclosed with fire barrier material have been determined for specific installation configurations by testing.

As part of its Thermo-Lag fire barrier test program, the applicant performed ampacity derating tests and submitted Phase I and II ampacity derating test results for NRC staff review on July 9, 1993, and April 25, 1995, respectively. The staff's review identified the following concerns associated with the applicant's Phase I and Phase II test results and their use: (1) the presence of negative ampacity derating test results, (2) the applicant's methods for deriving calculated ampacity correction factors based upon the test results, (3) the selection of the appropriate test method among the various configurations used during the tests, (4) the selection of one ampacity derating value given the variance in the weight and thickness of the tested Thermo-Lag enclosed conduits, (5) the applicability of the selected ampacity derating factor for different conduit sizes, (6) the utilization of derating correction factors in air drop raceway design calculations, (7) the nature of plant configuration controls which will assure that plant modifications will not invalidate test derived ampacity derating factors, and (8) the application of ampacity derating factors to future nonstandard raceway fire barrier configurations.

In its submittal of November 26, 1993, the applicant stated that the most significant finding was the assertion that the elimination of the annular air space between the conduit's outer surface and the inner surface of the Thermo-Lag barrier can significantly lessen the impact of the barrier on ampacity. This was accomplished by prebuttering the sections of the Thermo-Lag barrier before placing it over the conduit as required by the installation procedures. The applicant estimated that a Thermo-Lag protected 1-inch conduit containing a single 3-conductor #6 AWG cable, approximately 4.6 thermal ohms are added to the circuit for each 0.05 inch of air gap between the conduit and the barrier. Given that the total thermal resistance of such a configuration is approximately 20 thermal ohms, the effect of the gap is believed to be significant (an approximate 10 percent derating for the first 0.05 inch of gap). By eliminating this gap, TVA the applicant demonstrated a significant improvement in the ampacity performance of the system.

Ampacity correction factors (ACFs) in excess of 1.0 were unexpected, based on the staff's observation of Texas Utilities Electric (TUE) testing and on the original TSI results. Given the improved performance resulting from the elimination of the air gap as described above, the ACFs at or above 1.0 appear to be the result of Thermo-Lag's decreased thermal resistance to the air, which more than offsets the increased thermal resistance caused by the addition of the Thermo-Lag.

The applicant cited a Neher-McGrath equation for the thermal resistance from the surface to the surrounding air, which characterizes the decreased thermal resistance as a function of the greater surface area presented by the wrapped conduit and the higher emissivity of the Thermo-Lag fire barrier material. In the applicant's testing, 1-inch conduits (with a nominal 1.32-inch OD) were wrapped with a 5/8-inch-thick barrier (with the ±1/8-inch tolerance). The resultant new OD is approximately 2.8 inches, with a corresponding increase in the surface area. In addition, the surface emissivity of the dull white Thermo-Lag is well above that of a bare conduit. This arrangement further increases the conduit/fire barrier system's ability to dissipate heat.

The applicant noted that conduit tests performed with three conductors connected in series and powered single phase, as was required by both drafts 11 and 12 of IEEE Standard P848, did not produce meaningful results. The eddy currents and hysteresis losses in the conduit are of such a magnitude for this configuration (because of incomplete cancellation of magnetic fields) that the test is more a measure of the cable-and-conduit ampacity than the cable-in-conduit ampacity. The conduit losses are a function of the material properties of the steel used in its manufacture so that the magnitude of the losses are dependent upon the electrical resistivity and magnetic permeability parameters for specific conduit test segments.

Thus, the applicant performed additional testing with alternate conductor and power supply configurations in order to reduce the conduit losses. Conduit surface temperatures during these latter tests were approximately 60 °C (as compared to 80 °C when connected according to the draft standard), which was a result of a reduction in the above-mentioned losses.

The staff reviewed Phase I ampacity derating test data and concluded that negative ampacity derating test results or an ACF greater than 1.0 is possible, given the low emissivity of the barrier material and the absence of an air gap in the barrier construction. However, the purpose of the test procedure is to determine the additional ampacity derating value, which should be assigned to the specific Thermo-Lag fire barrier configuration. The selection of negative ampacity derating value would not represent a conservative finding, given other test results on the same test specimen with small but positive ampacity derating values. However, since the applicant will not be utilizing the ampacity derating values in question, this issue is considered resolved.

In response to the staff's concern regarding the use of the test results, the applicant, in its submittal of November 26, 1993, contends that because ACFs in excess of 1.0 were not originally anticipated, the results of early tests caused the applicant to revisit the basic ampacity relationships. Using the mathematical models constructed for bare 1-inch and 4-inch conduits, the applicant determined the allowable current for 3-conductor cables having standard ICEA diameters. By confirming that those calculated currents matched the ICEA published values, the model was then altered to evaluate cables having diameters equal to those under test, both with and without Thermo-Lag. The theoretical value of the ACF for each configuration could then be compared with the test results and serve as a guide for the selection of the final ACF. The values chosen for inclusion in the applicant's's Electrical Design Standard DS-E12.6.3, "Auxiliary and Control Power Cable Sizing," bound both the tested and calculated ACFs to ensure a conservative margin was maintained.

Although the information submitteded by the applicant clarifies the development of the ACFs cited in its submittal of July 9, 1993, the margins between the ACFs selected for the Thermo-Lag enclosed raceway configurations and the design-basis ampacity value have not been specified in any of the applicant's submittals.

The applicant also stated that on the basis of the results of its test program, it determined that the 3-conductor single-phase tests did not yield useful results because of the significant conduit heating that occurred. Aside from this factor, the greatest variation noted resulted from using multiple baseline conduits. Multiple baseline conduits were used to ensure that conduit effects were eliminated. No attempt was made to "match" the conduits used in the TVA tests. Thus, though the use of an even number of conductors (or three-phase power) may have sufficiently reduced the losses generated in the conduit, some conduit-to-conduit variations were still observed and ultimately became a factor in the decision to include margin in the selection of a final ACF. These variations may have resulted from the differing surface emissivities of the conduits.

Some of the variation was due to changes in cabling. In the 1-inch tests, the 4-conductor #6 AWG was replaced with a 3-conductor #6 AWG for the three-phase tests. In the 4-inch tests, the four 1-conductor 750-kcmil cables were replaced with the eight 3-conductor #6 AWG cables. In both cases, the thermal resistance attributable to the insulation and jacket material changed and thus had some effect on the resulting ACF.

Some variation from the single-phase to the three-phase tests may also be attributable to the criteria for current adjustment necessitated by the use of three individually adjustable power supplies in the latter test. Using the 5/8-inch wrap as an example, the ACFs shown in the table below were measured for each baseline unit.

ACFs for a 5/8-Inch Thermo-Lag Barrier per Baseline Conduit

Base	4/c	24/c	3-phase	Max □
1-inch base No. 1	0.982	N/A	1.002	2%
1-inch base No. 2	N/A	N/A	1.027	N/A
4-inch base No. 1	1.073	1.069	1.049	2.4%
4-inch base No. 2	1.038	1.033	1.018	2%

From reviewing the data in the preceding table, it can be seen that when the results are evaluated for the specific baseline conduit utilized, the variation is minimal. Also, the variations are approaching the accuracy of laboratory measurements.

In summary, the applicant has determined that either the 4-conductor or the 24-conductor tests yielded acceptable results without the complexity introduced by trying to keep three individual power supplies synchronized. Therefore, these tests are the most representative.

In response to the staff's concern regarding the tests performed, the applicant stated in its submittal of November 26, 1993, that the 4-conductor and 24-conductor single-phase tests were determined to be the most representative methodologies. Using the data from these tests, the lowest ACFs are shown in the table below, both in the measured form and rounded to the nearest 0.01.

Selection of Design Standard Ampacity Correction Factors

TSI Configuration	Lowest ACF	Based on	ACF Rounded to Nearest .01	Design Standard ACF
5/8"	0.982	1" Conduit Set No. 1	0.98	0.93
3/8" + 3/8"	0.977	4" Conduit Set No. 1	0.98	0.93
5/8" + 3/8"	0.967	1" Conduit Set No. 1	0.97	0.92

As can be seen from the measured data, the ACFs for the 5/8-inch and the 3/8-inch plus 3/8-inch Thermo-Lag systems differ by only 0.005. This figure is beyond the reliable accuracy maintainable during the tests and thus the applicant rounded the data points before selecting the ACF for use in its electrical design standard. From these data, it can be concluded that weight does not figure directly into the equations for ampacity.

In response to the staff's concern regarding conduit size, the applicant, in its submittal of November 26, 1993, stated that derating factors could have been developed for each conduit size. However, the scope of such a program would have been much more extensive without an appreciable benefit in determining the appropriate ACF. The intent of the standards working group in selecting the cable and conduit combinations specified in IEEE Standard P848 was to utilize raceways filled to their limit with a single circuit. The applicant found that the largest power circuits typically used were 750 kcmil (which would fill a 4-inch conduit) and the smallest conduit containing "significant" power circuits was 1 inch. The ACF was expected to vary somewhat as a function of conduit size because several components of the thermal circuit are also size dependent (i.e., thermal resistance from the cable to the conduit wall, thermal resistance to the air, and the thermal resistance of the barrier material). Thus, the draft standard required that tests be conducted for both 1-inch and 4-inch conduits so that the final ACF (for a given thickness of barrier material) would be the lower of the two and thus would envelope the range. Additional variances observed by the applicant may have been a function of the test configurations.

Although the testing of 3/4-inch and 5-inch conduits is not required by the draft IEEE standard, informal analysis by the applicant of the wrapped 3/4-inch conduit indicates that it would be able to carry more current than in the baseline condition. This is believed to be a fact because the application of Thermo-Lag results in a significant increase in the heat dissipating surface area, as previously discussed. Informal analysis of three 1-conductor 750-kcmil cables in a 5-inch conduit indicates that although the relative increase in surface is not great, the ACF is expected to vary by no more than 1 percent.

The final ACFs chosen for use in the applicant's design standards include margin, partly to account for the differing configurations, variances resulting from manufacturing, and maintenance of conservatism in the overall design.

Although the staff would agree that nominal differences in conduit sizes should not result in the need for significant margin, the applicant has not quantified the margin between the design ampacity limits and the ampacity derating value on the basis of test results. Although the applicant adequately addressed this concern, the staff will reexamine this issue upon completion of its ampacity test program.

In response to the staff's concern regarding the use of the air drop ampacity derating value, the applicant stated in its November 26, 1993, submittal that cable sizing (with respect to ampacity considerations) is a function of the load current, the load type, the raceway type, and the environment along its route. Because the raceway type and environment may change along the route of a cable, a series of ACFs often exists, each applicable to a single raceway configuration and environment. Thus, ACFs are determined for each segment and a corresponding set of values for the required ampacity of the cable under evaluation is calculated. This set is compared to the current that a cable can carry according to internal or industry standards for each raceway type for the cable being evaluated. As expected, cable sizing is dictated by the most limiting segment and ambient conditions along its entire route.

In its cable ampacity program, the applicant evaluates cables in each raceway segment and applies the necessary correction factors. In the past, no ampacity evaluation was required for power cable air drops because the ampacity in free air far exceeds that in a tray or in a conduit. Given the application of Appendix R wrap, the applicant will evaluate air drops containing power circuits that are wrapped in excess of 6 feet.

In response to the staff's concern regarding plant configuration controls, the applicant, in its submittal of November 26, 1993, stated that cable ampacity analysis is based on various standard ACFs, which are conservatively chosen to bound actual conditions of plant environment, load type, raceway type, and other attributes. When a cable displays marginally insufficient ampacity based on the standard ACFs, it is economically prudent to reevaluate the cable ampacity based on ACFs more closely matching the actual conditions of the individual cable. This standard practice was applied in the ampacity reevaluation that considered the Thermo-Lag fire wrap derating factors for cable trays. The following adjustments were utilized: (1) the actual motor nameplate load current, (2) the load factor for motor-operated valves, and (3) the percentage of cable fill in a cable tray.

The ACF values used for ampacity analysis must be documented in the ampacity calculation. Proposed changes to either the cable or the load procedurally require review and revision of the ampacity calculation. The cable tray fill factor is controlled through the computerized cable routing system (CCRS). The maximum percentage of fill for acceptable cable ampacity is established and becomes the tray fill limit according to the CCRS for the involved tray segments. Additional cables could only be added up to the tray limit.

In response to the staff's concern regarding nonstandard configurations, the applicant stated in its submittal of December 23, 1994, that the ACFs that will be used are based upon the extensive test programs conducted by both TUE and the applicant at Omega Point Laboratories (OPL) in San Antonio, Texas, and by the applicant at its own Central Laboratories Services Department (CLSD) facilities in Chattanooga, Tennessee. The ACFs used by the applicant for individually wrapped open-top ladder trays and wrapped air drops are based on the results of the TUE-sponsored tests. The ACFs used by the applicant for individually wrapped conduits are based on the results of the CLSD tests.

The results of the TUE tray tests are also being used to represent the common enclosure of trays that are horizontally adjacent (i.e., run side by side). This arrangement is consistent with the Stople model on which tray ampacities (given in ICEA publications) are derived in which the model considers heat being dissipated from the top and bottom surfaces only (and not from the sides). The TUE tests that were performed on ladder-type trays will also be used to represent solid-bottom trays. This application is conservative in that true solid-bottom trays do not have an air gap between the cables and the Thermo-Lag barrier because of the presence of the tray rungs.

The TVA-sponsored tests at OPL address the enclosure of ladder-type trays over which a sheet steel cover has been applied before the application of any barrier material. Those tests also include a vertical stack of trays within a common Thermo-Lag enclosure.

The final determination of the appropriateness of the final ampacity derating factors for the configurations expected to be installed at Watts Bar will be made upon completion of plant installation of the Thermo-Lag fire barriers and the ampacity derating testing program.

The applicant has selected the following cable ampacity derating factors for Thermo-Lag-enclosed electrical raceways at Watts Bar:

Raceway	Report No.	Ampacity Derating Value (%)	Excess Margin (%)
24" cable tray with 1/2" TSI configuration	TUE 12340-95169	31.5	See note
Large air drop with 5/8" + 3/8" TSI configuration	TUE 12340-95168	31.7	See note
1" conduit with 5/8" TSI configuration	TVA 93-0501	7.0	See note
1" conduit with 5/8" + 3/8" TSI configuration	TVA 93-0501	8.0	See note
4" conduit with 3/8" + 3/8" TSI configuration	TVA 93-0501	7.0	See note
24" cable tray with solid steel cover, with 5/8" TSI configuration	TVA 11960-97332	40	See note
3-24" trays in a common 5/8" TSI configuration	TVA 11960-97334	36	See note
3-1" conduits in a single row in a common 5/8" TSI configuration	TVA 11960-97335	8	See note
2 rows of 3-1" conduits in a common 5/8" TSI configuration	TVA 11960-97336	26	See note
1" conduit in a 5/8" TSI configuration mounted on a small Unistrut frame	TVA 11960-97768	12	See note
1" conduit in a 5/8" TSI configuration mounted on a large Unistrut frame	TVA 11960-97769	6	See note
2 rows of 3-1" conduits in a common 5/8" TSI configuration mounted on a large Unistrut frame	TVA 11960-97770	9	See note

Note : Excess ampacity margin is to be determined after Thermo-Lag fire barrier construction and testing has been completed.

For actual installations, the derating factors are typically applied to the ampacity values published in the ICEA tables for each cable size. It should be noted that because of the conservative factors used, the ICEA ampacity values are lower than the baseline values that have been typically determined by the ampacity derating tests. Cables are sized on the basis of the full load current multiplied by a factor of 1.25 in order to account for the voltage and the service factor requirements of the load. Upgrading of the cable size is another variable that may be required because of voltage drop consideration for long circuit lengths. Because most safety-related loads are operated intermittently, typically once a month during surveillance testing, the staff has judged it unlikely that cable-related failures could be induced as a result of incorrect ampacity derating factors over the interim period. The staff believes that the ampacity derating concern is an aging issue that is to be resolved over the long term. Therefore, the staff concludes that the use of interim ampacity derating factors is acceptable.

On the basis of the completion of the ampacity derating testing program and the resolution of the following three issues:

(1) the applicant's completion of the Phase III ampacity derating tests for the Watts Bar Thermo-Lag 770-1 fire barriers systems and its submittal confirming that the existing ampacity design margins are adequate and sufficient for each of these installed fire barrier configuration

(2) the applicant's confirmation that the existing ampacity design margins (Phase I and II ampacity derating tests) are adequate and sufficient for each of the Thermo-Lag 330-1 and 330-660 fire barriers to be installed at Watts Bar

(3) the NRC staff's confirmation that the test results using IEEE Standard P848 adequately bound the nominally different conduit sizes which are protected by Thermo-Lag fire barrier materials

The staff finds the use of the ampacity derating factors acceptable. Further, the staff concludes that no significant safety hazards exist due to the use of these interim ampacity derating factors on cables enclosed by Thermo-Lag fire barrier materials.

3.7.11 Chemical Composition of Electrical Raceway Fire Barrier Materials

In order to conform to the NRC's fire protection guidelines and regulations, the applicant will perform the chemical analysis testing on its Thermo-Lag 330-1 and 770-1 fire barrier materials. The test methods proposed are infrared (IR) spectroscopy and thermogravimetric analysis (TGV). The results of these tests will be used to evaluate the chemical composition of the Thermo-Lag fire barrier materials used to construct the fire barriers installed at Watts Bar and those which were used to construct the fire endurance and ampacity derating test specimens.

The IR test method will be used to identify organic and inorganic materials used to formulate the fire barrier materials. Each compound which is subjected to this type of testing can be characterized by its unique absorption spectrum and can be plotted as a percentage of transmittance or reflectance as a function of frequency. These data can be used to evaluate the variation in chemical composition of fire barrier materials within a typical lot and from lot to lot. The TGA is an empirical technique in which a substance is heated under controlled conditions and the mass of the material is recorded as a function of time or temperature. The mass loss over a specific temperature and in a controlled atmosphere over a specified time period provides composition analysis of the fire barrier material.

The applicant committed to perform these tests on a sample from each production lot of Thermo-Lag used to construct the ERFBS at Watts Bar. The sample size will be selected in accordance with the general inspection levels provided by Military Standard MIL-STD-105E, "Sampling Procedures and Tables for Inspection by Attributes."

The staff finds that the applicant's proposed means to chemically analyze the composition of the Thermo-Lag fire barrier materials used to construct the in-plant ERFBS and the fire endurance and ampacity derating test specimens will provide reasonable assurance that these materials are chemically the same; therefore, the method is acceptable.

3.7.12 Seismic and Material Properties of Electrical Raceway Fire Barrier Systems

Recognizing a need to address the seismic adequacy concern related to the Thermo-Lag fire barrier panels and conduit wraps, the applicant for Watts Bar had performed shake-table testing of some typical Thermo-Lag 330-1 protected cable tray and conduit configurations, and had tested Thermo-Lag 330-1 and 770-1 specimens to determine the mechanical properties of the material. On the basis of the tests, the applicant prepared (1) the structural evaluation criteria and (2) a general specification for installation, modification, and maintenance of electrical raceway fire barrier systems installed at Watts Bar.

This evaluation addresses the seismic adequacy of Thermo-Lag 330-1 panels and preformed conduit wraps and Thermo-Lag 770-1 mat. It also addresses the concern regarding appropriate consideration of Thermo-Lag material weight in the seismic adequacy calculations of the raceway supports and their anchorages.

Wyle Laboratories performed two series of shake-table tests for the applicant: Series 1 consisted of two specimens on the shake table: (1) Thermo-Lag 330-1 panels installed on three stacked cable trays and (2) Thermo-Lag 330-1 panels on a single cable tray with an air drop. Series 2 consisted of (1) Thermo-Lag 330-1 panels installed on seven-ganged conduits and (2) Thermo-Lag 330-1 preformed conduit wraps around a single conduit. Thermo-Lag was installed on all the configurations in accordance with the applicant's standard installation procedure (TVA General Engineering Specification G-98, "Installation, Modification, and Maintenance of Electrical Raceway Fire Barrier Systems," Revision 2, April 1995). The supports of the specimens were welded to the test table.

Control accelerometers were mounted on the test table near the base of the specimens. Six uniaxial accelerometers (two triaxial locations) were installed on all four configurations. In addition, two accelerometers were located on the vertical support of the single cable-tray configuration. Magnetic tape recorders provided records of each accelerometer's response.

The specimens were subjected to 30-second duration triaxial multifrequency random motions simulating the required response spectra (RRSs) corresponding to two operating basis earthquakes (OBEs), and one safe-shutdown earthquake

(SSE). The RRSs were generated considering the highest of the amplified floor response spectra in any of the safety-related structures. An environmental enclosure was installed on the test table to maintain the temperature of the specimens between 120 °F (49 °C) and 140 °F (60 °C) during the tests.

The tests indicated that there was no appreciable damage to Thermo-Lag 330-1 panels or preformed conduit wraps. A piece of Thermo-Lag material, less than 1 cubic inch, fell from the interior of the ganged conduit specimen after the second OBE test. These tests demonstrated that when the Thermo-Lag panels are completely enclosed by an outer layer of stress-skin, which is kept in position by additional tie-wires, the panels are not likely to get dislodged in pieces large enough to be of safety consequence during the postulated seismic events. Preformed sections of the single conduit were not enclosed by the exterior stress skin. However, they survived the seismic tests without damage.

Though the tested configurations represented typical onsite installations, the applicant recognized the potential departures that would be inherent in the as-built conditions. To analyze the conditions other than the tested configurations, the applicant performed mechanical properties tests (tests for tensile strength, flexural strength, shear strength, etc.) for Thermo-Lag 330-1. The applicant used the lower bound of these properties with a factor of safety of about 1.2 for analyzing various raceway configurations. The staff considers this safety factor to be relatively low. However, considering the conservatisms used in determining weights and seismic amplifications, and observations of no or minor damage during the seismic tests, the staff finds the evaluation procedure acceptable.

After reviewing the appropriateness of the seismic tests and the applicant's "general design criteria" related to the evaluation of Thermo-Lag fire barrier systems, the staff finds the applicant's approach for resolving the concern related to the fire barrier to be acceptable. A review of the applicant's "General Engineering Specification G-98" related to the installation and maintenance of the fire barrier systems at Watts Bar provides an assurance that the Thermo-Lag fire barrier systems will be installed and maintained consistent with the evaluation procedures.

The applicant plans to install Thermo-Lag 770-1 moldable conduit wraps covering the existing Thermo-Lag 330-1 in three specific areas in the auxiliary building (refer to Table 1 of TVA's design report on "Thermo-Lag Structural Evaluation," Revision 2, July 1995), where 3-hour fire rating is required. The Thermo-Lag 770-1 fire barrier material is moldable and does not have flexural strength. The 3/8-inch layers of the Thermo-Lag 770-1 fire barrier material are directly installed on the Thermo-Lag 330-1 conduit pre-formed sections and kept tightly attached to them by stainless steel tie-wires spaced every 6 inches. Thus, the mechanical properties essential for ensuring the retention of Thermo-Lag 770-1 material in place during a seismic event are the bonding capacity of this material to the Thermo-Lag 330-1 fire barrier material and the punching strength to ensure the retention of the tie-wires under the postulated seismic loadings. The lower bound punching strength and bond strength (between the Thermo-Lag 330-1 and 770-1 fire barrier materials) values were set as two standard deviations lower than the mean strength values obtained from the tests. An additional factor of safety of 1.2 was used on the established lower bound values for arriving at the acceptable values.

This process gave the acceptable punching strength as 12.2 lbf per inch, and bond strength as 4.4 psi.

The applicant analyzed the conduit sizes varying between 3/4 inch and 5 inches in diameter enclosed with four layers (two layers of 5/8-inch-thick Thermo-Lag 330-1 and two layers of 3/8-inch-thick Thermo-Lag 770-1) of Thermo-Lag, spanning 12 feet of unsupported length, subjected to peak spectral acceleration (horizontal and vertical) at the highest floor elevation in the auxiliary building. The seismic accelerations were vectorially combined and statically applied to the total dead loads of the combined assemblies. The maximum punching and bond values corresponding to the above allowable value determined from these analyses are 1.33 lbf per inch and 0.66 psi. Having reviewed the applicant's analyses, the staff finds that the added Thermo-Lag 770-1 fire barrier material will retain its position on the existing Thermo-Lag 330-1 fire barrier material, and will not fall in large enough pieces to cause a safety hazard for the nearby safety-related components and equipment. Singleton Laboratories performed the density tests on Thermo-Lag 330-1 material in accordance with ASTM D-1188. The applicant supplied the test specimens of 3/8-inch, 5/8-inch, and 11/4-inch panels and supplied preformed conduit wraps from the lots to be installed in the plant and the lots to be used in various other testing programs (i.e., fire tests, seismic tests and ampacity tests). The density of 58 panel specimens ranged from 56 to 75 lb per cubic foot, with an average of about 67 lb per cubic foot; and that of the 68 preformed conduit wraps ranged from 68 to 88 lb per cubic foot, with an average of about 78 lb per cubic foot. In the design evaluations of Thermo-Lag 330-1 panels and preformed wraps, raceway supports, and their anchorages, the applicant has used (TVA Design Standard DS-C1.6.16, "Structural Evaluation of Electrical Raceway Fire Barrier Systems," Revision 2 April 1995) density-values as 72 lb per cubic foot for the panels, and 84 lb per cubic foot for the preformed conduit wraps. The staff considers these density values adequate, provided (1) upperbound thicknesses are considered in computing the weight of Thermo-Lag and (2) the weight of the trowel-grade Thermo-Lag material is properly considered in the evaluations of raceway supports and anchorages. The examples provided in Design Standard DS-C1.6.16, indicate that the applicant has properly considered the weights of Thermo-Lag 330-1 material in such evaluations. In its design report "Thermo-Lag Structural Evaluation," Revision 2, July 1995, the applicant has appropriately considered the weight of Thermo-Lag 770-1 material in computing the loads on the applicable conduit supports and their anchorages.

On the basis of its review of the seismic test results of typical raceway configurations, the criteria set up for the structural evaluation of electrical raceway fire barrier systems, and the specification for installation, modification, and maintenance of the fire barrier systems, the staff concludes that if the Thermo-Lag 330-1 and 770-1 fire barrier systems are evaluated and installed in compliance with these criteria and this specification, they will be able to withstand the postulated seismic events at Watts Bar without significant damage to the fire barriers. The fire barriers (i.e., panels and conduit wraps) may crack and suffer minor damage, but will not cause undue hazard to the safety systems (including the protected cables, cable trays and conduits) in the vicinity of the installed fire barriers. The review also indicated that the applicant has properly considered the weight of the fire barriers in ensuring the seismic adequacy of the raceway supports and their anchorages.

~~3.8 Smoke Control and Ventilation~~

~~The applicant has evaluated all fire areas containing safe-shutdown equipment and the plant's capability to remove products of combustion from areas of fire origin. To support fire brigade activities, the applicant intends to use a combination of the normal ventilation exhaust system and portable fans to remove smoke from specific rooms.~~

~~The normal ventilation exhaust systems generally move smoke directly to the outside. When the normal exhaust paths are interrupted, either because of the isolation of one room or a group of rooms to contain the fire, or because of action of the fire brigade, most of the smoke will be confined within the rooms by the fire-rated barriers.~~

~~Hot gases caused by combustion within the rooms will be confined within the fire-rated barriers or controlled by automatic area suppression systems. When it is necessary to remove products of combustion from a room, the fire brigade will use portable fans and ducting equipment to remove cooled smoke from the fire-affected room and exhaust it either to the outside or to other rooms. From these rooms, smoke will be removed by the normal ventilation exhaust system or by natural venting to the outside. Where smoke is moved to other rooms, the normal ventilation rates or the natural vent openings in these rooms are sufficient to prevent smoke from stratifying or excessively concentrating in the rooms. The smoke will be removed from these rooms directly to the outside. When fixed ventilation equipment is used for removal of smoke, all necessary equipment and cabling from the fire area are separated by 1-1/2-hour fire-rated barriers.~~

~~Manual operations required to achieve and maintain safe shutdown will not be affected by the applicant's activities related to smoke removal from plant areas affected by fire. In addition, electrical equipment that is related to safe shutdown will also be unaffected by smoke removal operations. The staff concludes that the applicant's smoke removal concept conforms to the guidelines of Section D.4 of Appendix A to BTP (APCSB) 9.5-1 and is, therefore, acceptable.~~

~~3.9 Lighting and Communications~~

~~The applicant has committed to provide fixed, self-contained lighting consisting of fluorescent or sealed-beam units with individual 8-hour minimum battery power supplies in areas that must be manned for safe shutdown and in access and egress routes to and from all fire areas containing equipment required for safe shutdown. The illumination provided by the emergency lighting shall be sufficient to allow the operator safe access or egress to those plant areas where shutdown functions must be performed. In addition, the emergency lighting illumination level shall be sufficient to enable a qualified operator to perform the required manual action.~~

~~This design concept complies with the requirements of Section III.J and the guidelines contained in Section D.5.a of Appendix A to BTP (APCSB) 9.5-1 and is, therefore, acceptable.~~

~~The applicant has requested to deviate from its emergency lighting criteria inside the Reactor Building, yard area, and the turbine building. These deviations are addressed in Section 6.7, "Deviation - Emergency Lighting."~~

~~The applicant has provided several means of communications to support safe- shutdown operations. These means include (1) telephones, (2) a code, alarm, and paging system, (3) sound-powered phones, and (4) two-way radios. The in-plant radio repeater system will be the primary means of communication for performing manual shutdown actions and for fire brigade fire-fighting operations. This repeater system consists of three very high frequency (VHF) radio repeaters, remote control units, portable radios, and coaxial cable. These radios are primarily intended for use by operations and maintenance personnel, but one channel of the in-plant radio system has been designated for use by the fire brigade during fires or other emergencies. The VHF radio equipment is located on the turbine deck where it will be unaffected by auxiliary building fires. In addition to antennas on the roof of the turbine building, antennas are located in the control and turbine buildings, and two widely separated trunk lines feed the radio signal to redundant antenna systems located throughout the auxiliary building.~~

~~The staff finds that the applicant's proposed means of communications did not take any exceptions to Positions D.5.c and d of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~4.0 FIRE PROTECTION SYSTEMS~~

~~4.1 Water Supply and Distribution~~

~~The high-pressure fire protection water system at Watts Bar is common to both units and consists of four American Society of Mechanical Engineers (ASME) Section III seismic Category I high-pressure vertical turbine motor-driven pumps, each rated at 1590 gpm at 300 foot-head (130 psig). Each of these pumps can supply 50 percent of the required fire water flow to safety-related plant areas, to safe-shutdown-related areas, and to those areas that are either important to plant safety or where a fire could challenge reactor safety systems. Pressure control is provided by one pressure control valve downstream of the four pumps. The pumps are located in the seismic Category I intake pumping station with a 3-hour fire-rated fire barrier provided to separate two fire pumps from the other two. A single, automatically motor-driven, self-cleaning strainer is provided for each power train. Each strainer train filters the discharge flow of the two train-oriented fire pumps. Each strainer is capable of filtering 100 percent of the flow of the two fire pumps.~~

~~Each fire pump is powered from a separate 480-V shutdown board. In the event of loss of offsite power, each 480-V shutdown board is automatically connected to a separate emergency diesel generator. Supervised alarm circuits, indicating fire pump motor running condition and loss of line power on the line side of the switchgear, are provided in the main control room for each pump.~~

~~A 100-percent capacity, UL-listed, diesel fire pump is remotely located in the yard adjacent to the Unit 1 cooling tower. The diesel fire pump is capable of developing a flow of 2500 gpm (100-percent capacity) at 125 psig (404 foot- head) and 3750 gpm (150-percent capacity) at 81 psig (187 foot-head). The fire pump installation and its associated controller are installed in accordance with NFPA-20, "Installation of Fire Pumps." This fire pump automatically starts when the pressure in the underground fire water distribution piping drops below 50 psig.~~

~~The normal starting logic for the electric pumps is as follows. The pumps are in the automatic mode with the main control room hand-switch for one Train A and one Train B pump in the auto position and the hand-switch for the other pumps in the auto standby position. Upon receiving an auto start signal, the Train A pump will start, followed by the Train B pump after a 10-second delay. If, at any time 20 seconds after the receipt of an auto start signal, the pressure cannot be maintained above 105 psig, the Train A pump in auto standby will start, followed by the Train B pump after a 10-second delay.~~

~~Water supply for the electric fire pumps is taken from the Tennessee River and is considered unlimited for fire protection purposes. The diesel fire pump takes its water from the Unit 1 cooling tower basin and is considered to be an unlimited water supply for fire protection purposes (i.e., sufficient capacity for the diesel fire pump to pump at 150-percent capacity for 2 hours). An underground fire main loop serves both units. Sectional isolation valves allow maintenance to be performed on portions of the loop for one unit without affecting the fire-fighting capability of either unit. The sectional isolation valves in the underground loop are mechanically locked in position, and surveillance is placed upon supervision of valve position to ensure proper system alignment. The yard fire main loop is cross-tied between units. The high-pressure fire protection system is shared with the raw service water system. Automatic isolation valves isolate selected large raw cooling water loads from the high-pressure fire protection system when any of the fire pumps start.~~

~~All post-indicator-type valves (PIVs) are either sealed or locked open with a key-operated "breakaway" type lock. Curb box valves are not locked open. However, these valves are tamper resistant because they cannot be operated without a special "key" tool. This tool is not generally available, and, therefore, the staff has reasonable assurance that these valves will remain open.~~

~~The applicant's fire water supply system is designed to provide 100-percent fire-fighting capacity either with one electric pump and the diesel pump inactive or with the hydraulically least demanding portion of any loop main out of service. The fire pumps can supply water at design flow to the largest sprinkler or water spray system with design flow to non-isolated raw service water loads and can supply 500 gpm for hose streams.~~

~~Automatic sprinkler systems and hose station standpipe systems are separately connected to the yard main or to headers within buildings and are fed from each end of the building; therefore, a single failure cannot impair the sprinkler systems and the hose station at the same time.~~

~~As result of the concern with microbiologically induced corrosion (MIC), the applicant has adopted a permanent monitoring program for determining the performance of the standpipe and suppression systems. This permanent test capability has been installed for the hydraulically most remote areas of Watts Bar. The applicant has committed to perform this periodic testing of the high-pressure fire protection distribution system once a year for the first 3 years of plant operation and once every 3 years thereafter. The applicant will use the calculated design-basis pressure and flow requirements as the basis to monitor system performance. The applicant's design standard (DS-M3.5.1, "Pressure Drop Calculation for Raw Water Piping and Fittings") requires an 0.8-inch reduction of the actual pipe inside diameter and a Hazen-~~

~~Williams C factor of 55 for the sections of piping that are normally wetted. The purpose of these piping restrictions and the C factor of 55 is to predict a 40-year service life of the pipe. The data collected from these tests will be compared to the calculated values and trended to predict system degradation.~~

~~The applicant has committed to treat all raw water systems at Watts Bar with oxidizing biocides for MIC and a non-oxidizing biocide for clams and MIC. In addition, the applicant injects additional treatments into the system to provide the chemistry to clean up corrosion products and inhibit corrosion of carbon steel and copper/copper alloy materials. This chemical injection is coordinated with periodic system flushes in order to better distribute these biocides in normally stagnant portions of the system. In addition, using ultrasonic techniques, the applicant will semiannually monitor pipe wall thickness at several locations of the high-pressure fire protection pipe. This testing will maintain confidence in the structural integrity of the high-pressure fire protection piping.~~

~~In addition, the applicant performed a code compliance review and identified several areas in which the outside protection deviated from NFPA-24 (1973), "Outside Protection." Some of the more important code deviations identified were (1) check valves approved for fire protection service are generally used except for the check valves that isolate the raw water tank (NFPA-24, Section 3102); (2) post-indicator valves are not all 36 inches above the ground level (NFPA-24, Section 3303); (3) breakaway locks or the red seals are used on fire-related valves to administratively control their positions (NFPA-24, Section 3601); and (4) selection, coating and lining, and fittings of joints for piping is according to the applicant's design, construction, and modification procedures. These procedures provide guidance that conforms to or exceeds the code (NFPA-24, Sections 81 through 85).~~

~~The staff has reviewed the applicant's requested deviations from NFPA-24 and has determined that they will not affect the performance of the fire water supply system and, therefore, they are acceptable.~~

~~On the basis of its review, the staff concludes that the fire water supply system conforms to the guidelines of Section C.2 of Appendix A to BTP APCSB 9.5-1 and, therefore, is acceptable.~~

~~4.2 Active Fire Control and Suppression Features~~

~~4.2.1 Automatic Fire Suppression Systems~~

~~4.2.1.1 Sprinklers and Fixed Spray Systems With Closed Heads~~

~~Fixed water spray systems and sprinkler systems are designed in accordance with the applicable requirements of National Fire Protection Association Standard No. 13-1975 (NFPA-13), "Standard for Installation of Sprinkler Systems," and NFPA-15 (1973), "Standard for Water Spray Fixed System." In addition, the applicant performed a code compliance review and identified several areas in which the sprinkler and fixed spray systems deviated from the code. Some of the more important NFPA-13 code deviations identified were (1) no fire department pumper connections for the sprinkler systems (NFPA-13, Section 2-7), (2) use of water curtains to protect stair, elevator shaft, and equipment hatch openings where they could not be adequately sealed through the~~

~~use of a fire-rated door, damper, etc. (NFPA-13, Section 4-4.8), (3) sprinklers not provided below the double duct near cooler 1B-B and below open grating above the high-pressure fire pump flow control valve on elevation 692 ft 0 in. in the Unit 1 penetration room. This grating is approximately 5-feet wide by 15- feet long and is 15 feet above the room floor. Two sprinklers are installed approximately 3 feet above the grating. Plant procedures prohibit the storage of material on these grated walkways, so the gratings would be free of foreign obstructions. Due to the size of the grating (4 in. by 1 in.), flow from the sprinklers is not expected to be restricted by the grating. Therefore, the current sprinkler configuration in the Unit 1 penetration room is acceptable (NFPA-13, Sections 4-4.11 and 4-4.13). With respect to NFPA-15, the applicant did not take any exceptions to the code for the water spray systems protecting outdoor transformers, the hydrogen trailer, turbine hydrogen seal oil unit, and the turbine lube oil reservoir. The applicant used the guidance of NFPA-13 to design the directional fusible nozzle water spray systems used to protect certain charcoal filters and the reactor coolant pumps.~~

~~The staff has reviewed the applicant's requested deviations from NFPA-13 and 15 and has determined that they will not affect the performance of these systems and, therefore, they are acceptable.~~

~~The applicant has provided automatic preaction sprinklers in areas in which it is important to prevent accidental discharge of water. Operation of the preaction sprinkler system is initiated by a signal from the fire detection system in the area. Actuation can also be initiated manually by mechanical operation at the deluge valve. In addition, selected preaction systems at Watts Bar have manual actuation stations placed at strategic locations remote from the valve. These systems are provided with air supervision if the piping downstream of the system control valve supplies more than 20 sprinkler heads.~~

~~The applicant has provided automatic fixed water spray systems with closed heads for heating, ventilation, and air conditioning (HVAC) charcoal filter units in the auxiliary and control buildings, the reactor coolant pumps, the auxiliary boiler, the area of divisional interaction within the containment annulus space, and the cable tray penetrations through the turbine building/control building wall. These systems are actuated in a similar manner to the preaction sprinkler systems used at Watts Bar. In addition, automatic fixed water spray systems with open directional spray heads are provided for the transformers in the yard, the hydrogen trailer port, the main turbine oil tanks, the turbine head ends, the seal oil units, and main feedwater pump turbines 1A and B and 2A and B. Aqueous-film-forming foam systems are provided in the additional generator building and the security backup power building.~~

~~For both the preaction sprinkler and the fixed water spray systems, the only time water is discharged after system actuation is when the heat from the fire melts the fusible element of the sprinkler head.~~

~~Valves in the fire protection system are not electrically supervised; however, all valves whose misalignment would prevent proper operation of the system will be mechanically locked in their normal position. To ensure system alignment, the applicant has imposed operating requirements on supervision of valve position.~~

~~The following areas are equipped with automatic preaction sprinkler systems:~~

- ~~control building (elevation 755 ft 0 in.)~~

  - ~~mechanical equipment room~~
  - ~~janitor's closet~~
  - ~~corridor~~
  - ~~kitchen~~
  - ~~toilet~~
  - ~~locker room~~
  - ~~instrument calibration~~
  - ~~chart storage~~
  - ~~shift engineer's office~~
  - ~~record storage vault~~
  - ~~PSO engineering shop~~
  - ~~control room air cleanup and charcoal filters~~

- ~~control building (elevation 692 ft 0 in.)~~

  - ~~mechanical equipment rooms~~
  - ~~250-V battery room 1 and 2~~
  - ~~24-V and 48-V battery room~~
  - ~~communications~~
  - ~~corridor~~
  - ~~secondary alarm station~~

- ~~control building (elevation 729 ft 0 in.)~~

  - ~~cable spreading room~~

- ~~diesel generator building (elevation 742 ft 0 in.)~~

  - ~~pipe gallery and corridor~~

- ~~intake pumping station (elevation 710 ft 0 in.)~~

  - ~~electrical equipment room~~

- ~~reactor building~~

  - ~~reactor coolant pumps~~
  - ~~annulus area (division interactions)~~

- ~~turbine building~~

  - ~~numerous areas of building~~

- ~~auxiliary building (elevation 772 ft 0 in.)~~

  - ~~480-V board rooms~~
  - ~~125-V vital battery rooms~~
  - ~~480-V transformer rooms~~
  - ~~mechanical equipment rooms~~
  - ~~high-efficiency particulate air (HEPA) filter plenum rooms~~

- ~~auxiliary building (elevation 782 ft 0 in.)~~

  - ~~control rod drive equipment rooms~~
  - ~~pressure heater transfer rooms~~

- ~~auxiliary building (elevation 757 ft 0 in.)~~

  - ~~auxiliary control room~~
  - ~~6.9k-V and 480-V shutdown board rooms~~
  - ~~125-V vital battery rooms~~
  - ~~personnel and equipment access~~
  - ~~reverse osmosis equipment room~~
  - ~~reactor building equipment hatches~~
  - ~~reactor building access rooms~~
  - ~~emergency gas treatment rooms~~
  - ~~auxiliary control instrument rooms~~

- ~~auxiliary building (elevation 737 ft 0 in.)~~

  - ~~common area~~
  - ~~hot instrument shop~~
  - ~~heating and vent~~
  - ~~ventilation and purge air~~
  - ~~GF fuel detector room~~
  - ~~auxiliary building gas treatment system filters~~

- ~~auxiliary building (elevation 733 ft 0 in.)~~

  - ~~valve gallery~~
  - ~~decontamination room~~

- ~~auxiliary building (elevation 729 ft 0 in.)~~

  - ~~waste package areas~~
  - ~~fuel transfer valve room~~

- ~~auxiliary building (elevation 713 ft 0 in.)~~

  - ~~auxiliary building common area~~
  - ~~pipe gallery~~
  - ~~air lock~~
  - ~~volume control tank rooms~~
  - ~~titration room~~
  - ~~sample rooms~~
  - ~~radiochemical laboratory~~
  - ~~pipe gallery~~
  - ~~counting room~~
  - ~~containment purge air exhaust filters~~

- ~~auxiliary building (elevation 692 ft 0 in.)~~

  - ~~auxiliary feedwater pump rooms~~
  - ~~pipe gallery~~

- ~~charging pump room~~
- ~~safety injection pump rooms~~
- ~~cast decontamination collection tank room~~
- ~~spent resin tank room~~
- ~~valve gallery~~
- ~~waste evaporator package room~~
- ~~auxiliary waste evaporator packaging~~
- ~~corridor~~
- ~~chemical drain tank room~~

~~The staff has reviewed the design criteria and bases for the water suppression systems and concludes that these systems conform to the guidelines of Appendix A to BTP (APCSB) 9.5-1 and are, therefore, acceptable.~~

~~4.2.1.2 Gas Suppression System~~

~~A low-pressure total-flooding carbon dioxide (CO_2) system is provided for the following areas:~~

- ~~emergency diesel generator rooms 1A-A, 2A-A, 1B-B, 2B-B~~
- ~~turbine lube oil dispensing room~~
- ~~computer room~~
- ~~paint shop and storage room~~
- ~~auxiliary instrument rooms~~
- ~~480-V board room~~
- ~~lube oil storage room~~
- ~~fuel oil transfer room~~
- ~~lube oil purification room~~

~~The CO_2 systems are designed and installed according to NFPA-12, "Carbon Dioxide Extinguishment Systems." In addition, the applicant performed a code compliance review and identified several areas in which the fixed suppression systems deviated from the code. Some of the more important NFPA-12 code deviations identified were (1) the Class A supervised detection system does not have a secondary power source if the O-DPL-13-1 (main fire detection logic and control panel) power is lost (NFPA-14, Sections 1423 and 1431) and (2) diesel generator building pressure relief valves discharge to the exterior, but those for the power house and the relief valves for fill and equalizing lines do not. The power house main head vent and bleeder relief lines do discharge to the exterior. The staff has reviewed these requested deviations from NFPA-12 and has determined that they will not affect the performance of the CO_2 systems and, therefore, they are acceptable.~~

~~The CO_2 system is actuated by a signal from either the fire detection system in the area or a pushbutton station. Once a CO_2 system is activated, it actuates area alarms, the predischarge timer, the discharge timer, the master control valve, and the area selector valve (which permits the CO_2 to be discharged into the room or other selected area). In designing these systems, the applicant has considered personnel safety by providing the predischarge alarm to notify anyone in the area that CO_2 is going to discharge and by adding an odorant to the CO_2 to warn personnel that the system has been discharged.~~

~~Actuation of these systems causes selected fire dampers and doors to the protected area to close and the HVAC fans to the area to shut down ensuring that the minimum concentration of CO_2 is maintained.~~

~~The design basis for the areas protected by automatic CO2 are as follows: (1) auxiliary instrument rooms - the primary fire hazard is cables and is considered a deep-seated fire source; therefore, the system must have a 50- percent flooding factor per NFPA 12, 1973 Edition to maintain carbon dioxide concentration for a substantial period of time to assure complete extinguishment In addition, the leakage from the room must be limited and the system must maintain at least a 50-percent concentration for 15 minutes; (2) computer room (CO_2 system is provided for property protection) - the system must achieve a 30-percent concentration within 2 minutes and 50-percent concentration within 7 minutes after system discharge; (3) diesel generator engine rooms - the primary fire hazard is a surface fire (diesel fuel); therefore, the system must achieve a 34-percent concentration within 1 minute and maintain at least a 34-percent concentration for 20 minutes; (4) diesel generator electrical board rooms (CO_2 systems are provided for property protection) - the system must achieve a 30-percent concentration within 2 minutes and 50-percent concentration within 7 minutes after system discharge; and (5) lube oil storage and fuel oil transfer rooms (CO_2 system is provided for property protection) - the system must achieve a 34-percent concentration within 1 minute.~~

~~The applicant's CO_2 storage tank for supplying CO_2 to the diesel generator system is located in the diesel generator building. The diesel generators are protected from the effects of a postulated failure of this tank by an 18-inch-thick reinforced concrete wall. The vent path for the tank room for the storage tank compartment is through a set of double doors which lead into the stairwell and, if needed, through another set of double doors which open to the atmosphere from the stairwell.~~

~~The CO_2 for the balance of the plant is supplied from a storage tank in an underground vault in the yard. The failure of the tank cannot pose a threat to any safety-related areas or structures.~~

~~The staff finds that the applicant's design criteria and bases for the automatic CO_2 fire suppression systems did not take any exceptions to Position C.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~4.2.2 Manual Suppression Capability~~

~~4.2.2.1 Hose Stations~~

~~Manual hose stations are located throughout the plant to ensure that an effective hose stream can be directed to any safety-related area in the plant. The system is designed according to the requirements of NFPA-14 (1974), "Standpipe and Hose System for Sizing, Spacing, and Pipe Support Requirements," except for those hose stations in certain areas of the plant in which the applicant has requested a deviation to exceed the 100-foot hose spacing limitation. These deviations are discussed in Section 6.9.4, "Deviation - Manual Hose Stations."~~

~~In addition, the applicant performed a code compliance review and identified several areas in which the manual fire-fighting hose stations and standpipe system deviated from the code. Some of the more important NFPA-14 code~~

~~deviations identified were (1) the standpipes located on elevations 676 ft, 692 ft, 713 ft, 729 ft, 757 ft, 772 ft, and 782 ft of the auxiliary building are supplied with 3-inch pipe rather than the 4 inches required by the code and NRC fire protection guidelines; and elevation 755 ft of the control building has 2-1/2-inch supply piping. These pipe sizes were verified as adequate by hydraulic calculation (NFPA-14, Section 212); (2) 1-1/2-inch hose connections at each floor for Class II service are not provided at each floor level; however, plant locations can be reached by available hose len44gths at existing stations (NFPA-14, Section 342); (3) hose outlets are only located in or near enclosed stairways in the control building. No other building has enclosed stairways (NFPA-14, Section 412); (4) valves approved for fire protection service and of the indicating type are provided at the main riser, except for 0-26-677 and -690 (NFPA-14, Sections 413 and 622); however, these systems can be isolated and do not preclude the ability to provide hose stream coverage in the same location; (5) since the hose stations are for fire brigade use only, the pressure-reducing devices at the hose stations have been deleted from the design (NFPA-14, Section 442); (6) high-pressure valves, pipes, and fittings not used, even though system spikes of up to 190 psi occur due to pump start surges. This is acceptable and in accordance with ANSI B31.1 systems requirements (NFPA-14, Sections 625, 631, and 641); and (7) pushbutton fire pump start stations at the hose station locations inside containment will alarm in the control room, and water flow alarms are not provided on standpipes. The pushbutton stations will provide adequate notification of hose station use to the main control room; therefore, water flow alarms are not needed (NFPA-14, Section 67).~~

~~The staff has reviewed the requested deviations from NFPA-14 and has determined that they will not affect the performance of the hose stations and the standpipes and, therefore, they are acceptable.~~

~~The fire hose stations have electrically safe nozzles approved (UL/FM) for use on fire involving energized electrical equipment (e.g., cable trays, motor control centers, switchgear). In addition, the applicant has made provisions in the plant design to supply water at sufficient pressure and capacity to the standpipes, hose stations, and hose connections for manual fire fighting in areas required for safe plant shutdown in the event of a safe-shutdown earthquake.~~

~~The staff finds that the applicant's design criteria and bases for manual fire- fighting standpipe system and hose stations did not take any exceptions to Position C.3 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~4.2.2.2 Fire Extinguishers~~

~~The applicant has not installed portable fire extinguishers in accordance with the spacing and location criteria specified by NFPA-10 (1975), "Portable Fire Extinguishers." The applicant has committed to provide portable fire extinguishers of a size and type compatible with specific hazards and to locate them strategically throughout the plant for use by the fire brigade. In addition, the applicant has committed to inspect these fire extinguishers on a quarterly basis.~~

~~The staff finds that the applicant's proposed application and the distribution of portable fire extinguishers throughout the plant, for fire brigade use~~

~~only, provides reasonable assurance that the fire extinguishers will be readily available and quickly accessed in the event of a fire emergency and, therefore, the applicant's solution is acceptable.~~

~~4.3 Fire Detection Capability~~

~~The fire detection system consists of initiating devices, local control panels, a remote transmitter-receiver providing a remote multiples (MUX) function, computerized multiplex central control equipment, and power supply. The types of detectors used are photoelectric and ionization for products of combustion--thermal and infrared. The fire detection and alarm system also monitors duct detectors and devices for monitoring fire suppression system piping integrity, water or~~ $\cancel{CO_2}$ ~~flow, and valve and door position indication. Fire detection systems will give an audible and visual alarm and will also annunciate in the control room. Local audible or visual alarms or both are also provided.~~

~~The system is electrically supervised for ground and open wiring faults in the detection, power supply, alarm, and MUX data transmission circuits. Supervision is Class A in the detection and data transmission circuits. A wiring fault in these circuits results in an audible and visual trouble indication, both locally and at control locations. The fire detection system is powered from two 120-V ac power sources. The primary power supply is from a Class 1E power source with the standby power from the standby emergency diesel generator. An interim power supply is provided when an automatic transfer from the main power to the standby power takes longer than 30 seconds. The interim power source consists of batteries that provide power, for a minimum of 4 hours, to the remote transmitter and receiver modules only.~~

~~The system processes the following types of signals: (1) alarm, a signal indicating the actuation of a smoke or heat detector or the sensing of flow through fire suppression systems, and (2) trouble, a signal indicating a fault condition in the proprietary protective signaling system.~~

~~A central processor unit (CPU) of the computerized multiplex central control equipment communicates with the local control panels via remote transmitter-receiver units over a looped circuit. The transmitting equipment allows the processor to interrogate the local control panels and to receive data from these panels. When an initiating device changes state from normal to alarm of trouble, the change is detected by the local control panel, and when the next interrogation occurs, the remote transmitter-receiver transmits the status change. This status change is evaluated by the CPU, and visual and audible indications are annunciated in the control room. A second CPU is provided as backup and is located in a constantly attended location as an installed spare in case the primary processor in the main control room fails.~~

~~The staff has reviewed the fire detection systems to ensure that fire detectors are adequate to provide detection and alarm of fires that could occur. It has also reviewed the fire detection system's design criteria to ensure that they conform to the applicable sections of NFPA-72D (1975), "Installation, Maintenance and Use of Proprietary Signaling Systems," and NFPA-72E (1974), "Automatic Fire Detectors."~~

~~In addition, the applicant performed a code compliance review and identified several areas in which the manual fire-fighting hose stations and standpipe system deviated from the code. Some of the more important NFPA-72D and 72E code deviations identified were as follows:~~

~~(1) The operation and supervision of fire alarms are not the primary functions of control room operators; operators are responsible for all control room alarms (NFPA-72D, Section 1223).~~

~~(2) Water flow is not performed through the test. A 2-inch main drain test is conducted annually (NFPA-72D, Section 1233).~~

~~(3) The fire alarm console in the main control room was a UL-listed device; however, the applicant has modified the this console by adding non-UL-listed panels known as A-B switchover panels, which allow a quick changeover to the installed spare control system. This option is not commercially available and does not degrade the system. The two alerting tone volume control devices have been adjusted to meet the requirements of the human factors analysis for the main control room (NFPA-72D, Sections 1213 and 2022).~~

~~(4) Actions upon receipt of a fire alarm, signal the fire department; the brigade is not immediately notified. Upon receipt of an alarm from a cross-zoned detection system, an individual (auxiliary or fire operator) is dispatched to the area to determine the cause of the alarm. If a fire exists, the individual notifies the main control room and control room operators notify the plant fire brigade. If both detection zones of a cross-zoned detection system alarm, the fire brigade is notified immediately (NFPA-72D, Section 1251).~~

~~(5) The system is not rated to operate at 85 percent of rated voltage (NFPA-72D, Section 2036).~~

~~(6) The fire alarm system has the emergency diesel generators as the automatic secondary power supply. The UPS backup and batteries within the fire alarm console supply selected devices in the fire alarm console (NFPA-72D, Sections 2223 and 2231).~~

~~(7) Low header pressure on Zones 302, 303, 304, 313, 314, 316, 317, 376, 377, 399, 400, 423, and 431 are annunciated as a trouble condition and not a as a supervisory signal at the fire alarm console (NFPA-72D, Sections 2461, 2462, and 3422).~~

~~(8) Signal attachments and circuits (pressure switches) can be removed or tampered with and not cause an alarm. The site personnel access control and the work control system provide adequate assurance that work on such devices is properly controlled and documented. These devices are in controlled plant areas which reduce the likelihood that the device will be maliciously by-passed (NFPA-72D, Section 3423).~~

~~(9) Sprinkler system control valves are not electrically supervised; they are locked open or sealed open and periodically inspected instead (NFPA-72D, Section 3442).~~

~~(10) Both visual and recorded displays meet the code, but records are not preserved for later inspection. Plant procedures have reporting requirements for conditions adverse to quality. These procedures require an adverse condition report to be completed before the end of the shift on which the problem was identified, and documentation from the fire alarm printout would be available to support the adverse condition report (NFPA-72D, Section 4111).~~

~~(11) The transmission of an alarm signal to the fire alarm console, because of a wire-to-wire short circuit, cannot be recorded. A wire-to-wire short will generate a trouble signal which requires corrective action (NFPA-72D, Sections 4112 and 4311).~~

~~(12) Fire detection has not been provided in the diesel generator building stairway D1, bathroom, and CO^2 storage room on elevation 742 ft, and the corridor and radiation shelter room on elevation 760 ft. In addition, no detection capability is installed under the grating and duct work in Unit 1 penetration rooms on auxiliary building elevation 692 ft, the airlock, specific auxiliary building pump room labyrinths, and the auxiliary building elevator shaft and associated auxiliary elevator equipment (NFPA-72E, Section 2-6.5).~~

~~(13) Smoke detectors in the high ceiling areas of the plant are not installed alternately on two levels. The high ceilings are addressed by reducing the spacing of the detectors at the ceiling level. This reduced spacing is used on auxiliary building elevations 692 ft, 713 ft, 737 ft, 757 ft, and the waste packaging room (NFPA-72E, Section 4-4.5.2).~~

~~(14) Use of duct detectors in lieu of area detectors in the reactor building upper and lower compartment coolers; however, regulatory requirements for detectors met in reactor building (NFPA-72E, Section 8-1.1.2).~~

~~(15) Duct detectors not provided per NFPA-90A requirements; fans serving the area of the plant that is on fire are shut down manually to ensure that air flow will not prevent fire dampers from closing (NFPA-72E, Section 8-1.2.1).~~

~~The staff has reviewed the requested deviations from NFPA-72D and 72E and has determined that they will not affect the performance of the hose stations and the standpipes and, therefore, they are acceptable.~~

~~The staff finds that the applicant's design criteria and bases for the plant fire detection system did not take any exceptions to Position C.1 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.0 FIRE PROTECTION FOR SPECIFIC PLANT AREAS AND HAZARDS~~

~~5.1 Containment~~

~~The major fire hazard within the containment is the lube oil system for the reactor coolant pump (RCP). To prevent a fire from oil leakage, the applicant has provided an oil collection system for each RCP. This system on each RCP collects oil from all potential leakage locations, including the RCP oil lift pump, system piping, overflow lines, the lube oil cooler,oil fill and drain lines, flanged connections on the oil lines, and the lube oil reservoirs.~~

~~Each RCP oil collection system consists of spray shields/deflectors, a collection basin, a lift pump collection tray, a lower bearing collection tray and drain, drain piping, and a closed, vented container (reactor building floor and equipment drain sump).~~

~~The RCP oil cooler, oil reservoirs, and the oil lift pump are enclosed inside a sheet metal box; these are designed to prevent high-pressure oil from spraying onto other components. The bottom panel of the box around the oil lift pump is equipped with a 3-inch drain pipe, which drains into the collection basin (RCP platform). The upper oil reservoir, located near the top of the RCP motor, is the largest single potential leak site. It is totally enclosed on the RCP motor side and any oil leakage on this side is directed down the motor casing and is deflected by a metal skirt onto the collection basin. The shielding box around the oil cooler is designed to perform in the same fashion as the shielding box surrounding the lift pump. Oil from other potential leakage sites will drip or be deflected onto the collection basin.~~

~~The drain piping from each RCP's oil collection basin is directed to a drain header. The drain header runs through the shield wall and into the raceway area inside primary containment and runs through the floor into the 1600- gallon-capacity sump. As required by Appendix R, the sump is a closed container and is equipped with a flame arrester on the vent line. The sump has sufficient capacity to hold the entire RCP oil inventory of all four RCPs. The RCP pumps, lubricating oil systems, oil spray shields, oil collection basins, drain piping, and containment sump are designed to seismic Category I requirements so as not to fail during a safe-shutdown earthquake (SSE).~~

~~In addition, each RCP contains a control loop for the oil reservoir level indication. An annunciator for high or low oil level is located in the main control room. Each control loop contains two indicators and these indicators are set to give early warning of a loss of lube oil. An alarm is annunciated in the MCR if 12 or more gallons of oil are lost from the reservoirs.~~

~~Each of the four RCPs is protected by a fixed fire suppression and detection system. A heat collection hood is installed directly above the RCP motors. Each of the four RCPs is protected by a separate closed-head preaction automatic water spray system that is installed under this hood. Each system has a ring header containing eight nozzles. The header is located approximately 4 feet above the top of the RCP motor and the nozzles, which actuate at 500 °F (234 °C), are oriented so as to provide optimum coverage of the RCP motor from above. In addition, there are four rate-compensating/fixed- temperature spot-type thermal detectors located above the RCP motors on the bottom side of the heat-collection hood. These detectors are class A supervised, have a thermal rating of 200 °F (93 °C), and are alarmed and annunciated in the main control room. In the event of a fire, this hood acts as a ceiling, forcing the heat to stall around the detectors and the suppression nozzles, thus reducing the response time of these fire protection devices. Areas of divisional interaction within the annulus area will be protected by an automatic fixed water-spray system designed according to NFPA-15, except that conventional sprinkler heads will be used. In addition, all exposed cables within this area will be coated with a flame retardant material. The divisional interactions involving redundant post-fire safe-shutdown functions~~

~~necessary to achieve safe shutdown in the event of fire will be provided with a 1-hour fire-rated fire barrier.~~

~~The fixed automatic water-spray systems for the RCPs and the divisional interactions within the annulus area are designed in accordance with NFPA-15 (1973), except that these spray systems do not use open head nozzles and are provided with thermally actuated nozzles.~~

~~A standpipe and hose system, designed according to NFPA-14, has been provided to complement the fixed-water suppression system in the reactor building annulus. The standpipe system within the containment will normally be dry and arranged to admit water when remote control devices at each hose station are manually operated.~~

~~The containment and annulus fire detection system is designed according to NFPA-72D with Class A supervision. Thermal detectors are provided for the charcoal filters and HEPA filters, and ionization detectors are provided for divisional cable interaction areas.~~

~~Fixed water-spray systems are provided for the charcoal and HEPA filters in the lower containment air-cleanup units. Ionization duct detectors are provided for each lower containment cooling unit and each upper compartment cooling unit. In addition, ionization smoke detectors are provided for the exhaust ducts serving the containment purge and air exhaust systems and the emergency gas treatment system. In the annulus area, heat and smoke collectors ensure that fire detectors will respond quickly.~~

~~The applicant did not identify any deviations to separation requirements of Section III.G of Appendix R to 10 CFR Part 50 and has committed to install non-combustible radiant energy heat shields in those areas inside the containment where there are interactions between redundant safe-shutdown trains. The staff has reviewed the applicant's fire hazard analysis and the fire protection provided for the area inside containment.~~

~~The staff concludes that the fire protection for this area is appropriate and conforms to the guidelines of Appendix A to BTP (APCSB) 9.5-1 and is, therefore, acceptable.~~

~~5.2 Control Room Complex~~

~~5.2.1 Control Room~~

~~The control room complex is separated from other areas of the plant by 3-hour fire-rated barriers. The control room is separated from adjacent rooms in the control room complex by 1-hour fire-rated barriers. Doors between the control room and the turbine building and the control room and the auxiliary building are 3-hour fire-rated fire doors. These doors are normally closed, locked, and operated by card readers. Operation of these doors is alarmed in the main control room. Administrative procedures will be used to ensure that the doors are not left open or propped open during maintenance or plant operation. All other doors in the complex are 1 1/2-hour fire rated. Three-hour fire dampers are installed in ducts that penetrate the wall from the control building to the auxiliary building.~~

~~Fire extinguishers are provided in the main control room. Standpipe hose stations are located in stairwells adjacent to the main control room and in stairwells from the turbine building.~~

~~Ionization smoke detection is provided in selected control room cabinets. In addition to the areawide ionization detectors installed in the main control room, ionization duct detectors are provided in the main control room ventilation system. No smoke detectors are installed above the control room suspended ceiling. The concealed space is devoid of combustible material and therefore does not require detection. Any future modification which adds combustible material above the false ceiling would require the addition of smoke detection in this space.~~

~~Smoke detection which is provided in the control room ventilation intake alarms locally and in the main control room. The control room ventilation air intakes are provided with remotely controlled dampers to prevent smoke migration from an external fire event from entering the control room. Smoke is manually vented from the control room by opening doors and using the fire brigade's portable smoke control equipment.~~

~~Carpeting and a dropped suspended ceiling with a vinyl dust cover are to be installed in the control room. The carpeting in the control room has been tested in accordance with NFPA-253 (1984), "Standard Method of Test for Critical Radiant Flux of Floor Covering Systems." The carpet selected by the applicant for use in the control room has a critical heat flux (CHF) in excess of 0.45 w/cm^2. This CHF provides reasonable assurance that the control room carpet will not contribute to a spread of fire in the control room; therefore, the staff finds the use of carpeting in the main control room acceptable. Below the main control room consoles, a 3-foot by 4-foot access walkway extends approximately 4 feet down into the cable spreading room. This walkway is separated from the cable spreading room by a 3-hour fire-rated fire barrier. The applicant stated that all safety-related cabling that passes through the enclosed walkway from the spreading room to the termination strips on the main control room cabinets is enclosed in metal cable gutters to a point just above the main control room floor where the cable gutters meet cable risers in the control room cabinets. The cabling enters the metal gutters from the spreading room cable tray system at the bottom of the enclosed raceway, passing through 3-hour fire-rated penetration seals. Because the metal gutters enclose the cables to a point just above the control room floor elevation, the cables are not in a fire-propagating configuration. Existing manual fire-fighting capability should provide adequate fire protection for this area. The staff finds that the fire protection for the control room complex conforms to the guidelines of Position D.2 to Appendix A of APCSB 9.5-1 and is, therefore, acceptable.~~

~~5.2.2 Auxiliary Control Room~~

~~The auxiliary control room (ACR) is separated physically and electrically (by transfer switches) from the main control room and the cable spreading room. In the event of a damaging fire in the main control room, the cable spreading room, or the two auxiliary instrument rooms, plant shutdown capability can be maintained from the ACR. Curbs are installed at all four auxiliary control instrument room openings to prevent the possibility of a fire involving a~~

~~flammable or combustible liquid spill from impacting all four channels of both trains of safe-shutdown capability.~~

~~The room is constructed of reinforced concrete and is fire rated for 2 hours. Doors, dampers, and penetration seals installed in the openings of this room have an equivalent fire rating. The ACR and its instrument rooms are protected by automatic preaction sprinklers, and areawide ionization detection is provided.~~

~~The staff finds that the fire protection for the ACR and ACR instrument rooms is in accordance with Appendix A to BTP (APCSB) 9.5-1 and is, therefore, acceptable.~~

~~5.3 Cable Spreading Room~~

~~The cable spreading room is shared by both units. The walls, floors, and ceiling are designed to have a fire rating of 3 hours. An automatic preaction sprinkler system has been provided. The system has two horizontal levels in the cable spreading room: (1) an upper level near the ceiling and (2) an intermediate level approximately halfway between the floor and ceiling. The sprinklers in the intermediate level are staggered horizontally between the upper level sprinkler grid. Portable fire extinguishers are located inside and immediately outside the cable spreading room and are readily available for incipient fire fighting. Hose stations are available from the stairwells located at either end of the spreading room and from the turbine building. A cross-zoned ionization detection system is also installed in this area, and two remote and separate entrances are provided for fire brigade access.~~

~~All exposed non-IEEE-383 qualified cable is coated with a fire retardant to minimize fire propagation. In the event of a fire in the cable spreading room, plant shutdown capability can be maintained from the ACR, which is completely separate and independent of these areas.~~

~~The staff concludes that the applicant's proposed fire protection features for the cable spreading room did not take any exceptions to Position D.3 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.4 Switchgear Rooms~~

~~The trained 6.9-kV and 480-V switchgear rooms are separated from each other and from other areas within the auxiliary building by 2-hour fire-rated barriers and from the control building by 3-hour fire-rated barriers. Each room is provided with a full-area-coverage automatic preaction sprinkler system that is actuated by a cross-zoned areawide ionization smoke detection system. Water-spray shields have been installed as necessary to protect safety-related electrical equipment against the effects of inadvertent or advertent actuation of the automatic suppression system.~~

~~The staff concludes that the applicant's proposed fire protection features for the essential switchgear rooms provide an equivalent level of fire safety to Position D.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.5 Battery Rooms~~

~~The vital battery rooms (I-IV) are separated from all other plant areas by 3-hour fire-rated barriers. Each battery room has a ceiling vent directly exhausting to outside the building. This exhaust system is designed to maintain the hydrogen concentration below 2 percent by volume within the battery rooms. The operation of these exhaust fans is alarmed and annunciated in the main control room. Portable fire extinguishers and hose stations are available in the area of these rooms for manual fire fighting. Areawide ionization smoke detectors and a manually actuated sprinkler system are in each vital battery room. The staff finds that the applicant's proposed fire protection features for the plant vital battery rooms did not take any exceptions to Position D.7 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.6 Turbine Building~~

~~The turbine building oil hazards are protected by fixed water-spray systems. Cable tray penetrations through the 3-hour fire-rated fire barrier separating the turbine building from the control building are sealed with 3-hour fire-rated penetration seals and are provided with automatic water curtain protection on the turbine building side.~~

~~The staff concludes that the applicant's proposed fire protection features for the turbine building did not take any exceptions to Position D.8 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.7 Diesel Generator Areas~~

~~The diesel generator building is remotely located and is not adjacent to any other safety-related building or structure. Each diesel generator with its associated 480-V board room and equipment are separated from each other by 3-hour fire-rated barriers. Each diesel generator and its 480-V board room are protected by an automatic total-flooding~~ CO_2 ~~fire suppression system (see Section 4.2.1.2, "Gas Suppression System"). The pipe galley and the corridor are protected by a preaction sprinkler system. Each diesel generator compartment is provided with thermal fire detection, and its associated 480-V board room is provided with ionization fire detection. Portable fire extinguishers and hose stations are available to support manual fire fighting in these areas.~~

~~The staff finds that the applicant's proposed fire protection features provided for the diesel generator area did not take any exceptions to Positions D.5 and D.9 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.8 Diesel Generator Fuel Oil Storage Areas~~

~~The above-ground diesel fuel oil storage tanks are located in a remote yard more than 50 feet away from any safety-related building or structure. Dikes surround the area around the tanks. This diesel fuel storage facility is designed to meet NFPA-30 (1973), "Flammable and Combustible Liquids Code." The safety-related 7-day diesel fuel storage tanks are buried.~~

~~The staff finds that the applicant's proposed fire protection features provided for the diesel fuel oil storage areas did not take any exceptions to~~

~~Position D.10 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~In the diesel generator building at elevation 742 ft 0 in., the lube oil storage room is in a 3-hour fire-rated fire compartment. The 3-hour fire-rated doors are in the open position and close only when the thermal link above the door melts or the CO_2 system for the room discharges. To conform to the guidelines of Section 6-6.3.2 of NFPA-101 (1976), as well as of Section 4-4.1.2 of NFPA-30, these doors should be self-closing. At each opening, the applicant installed hollow side-hinged metal doors, which are normally closed. These doors will prevent smoke and hot gases from a fire from passing through the opening until the fire doors close and the fire suppression system actuates. These doors and the curbs at the door openings will prevent material from being placed in the path of the sliding fire door and preventing it from closing completely.~~

~~The staff concludes that the fire door configuration in the lube oil storage room complies with Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 and is, therefore, acceptable.~~

~~5.9 Safety-Related Pump Areas~~

~~5.9.1 Component Cooling Water System (CCWS) Pump Area~~

~~The two Train A CCWS pumps are separated from the two Train B pumps and the spare by a 1-hour fire-rated fire barrier that extends 3 feet above the highest point of the pumps. Raceways containing the redundant circuits for the CCWS pumps are separated by 20 feet or more or by 1-hour fire-rated barriers. Train B control circuits routed in conduits above or near the edge of the pump fire barrier are enclosed in a 1-hour raceway fire barrier system. A ceiling-level preaction sprinkler system is provided for cable tray and general area coverage. Automatic sprinkler coverage has also been provided under the pipebreak barrier for the motor-driven auxiliary feedwater pumps and under the mezzanine for all five CCWS pumps. Cross-zoned ionization smoke detectors are provided to actuate the preaction suppression systems and provide early warning in case of fire. The application of a partial height fire barrier between these pumps is a deviation from Appendix R Section III.G fire protection requirements. This deviation is discussed in Section 6.5, "Deviation - Partial Fire Wall Between Component Cooling Water System Pumps."~~

~~5.9.2 Charging Pumps~~

~~Each charging pump is located in its own 2-hour fire-rated fire compartment. The pump rooms and the corridor outside these rooms are protected by automatic ionization fire detection and an automatic preaction sprinkler system. However, the sprinkler protection is not extended into the entrance labyrinths to the pump rooms. Hose stations are located in the corridor leading to these rooms and are available to support manual fire fighting inside these pump rooms. The lack of full-area sprinkler coverage is a deviation and is discussed further in Section 6.8, "Deviation - Lack of Total Area Suppression and Detection."~~

~~5.9.3 Auxiliary Feedwater Pumps~~

~~The steam-driven auxiliary feedwater pump is located on auxiliary building elevation 692 ft 0 in. This pump is located in its own 2-hour fire-rated fire compartment. The pump room is protected by automatic ionization fire detection and an automatic preaction sprinkler system. Hose stations are located in the corridor leading to this room and are available to support manual fire fighting inside the pump room.~~

~~The redundant motor-driven auxiliary feedwater pumps are located on auxiliary building elevation 713 ft 0 in. The fire area in which these pumps are located is protected by an automatic preaction sprinkler system. Automatic ionization detection is provided in the area, and hose stations are available in the area to support manual fire-fighting operations.~~

~~The staff concludes that the applicant's proposed fire protection features provided for the turbine-driven auxiliary feedwater pump provide an equivalent level of fire safety to Position D.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.9.4 Residual Heat Removal Pumps~~

~~Each residual heat removal (RHR) pump is located in its own 2-hour fire-rated fire compartment. The pump rooms and the corridor outside these rooms are protected by automatic ionization fire detection. Hose stations are located in the corridor leading to these rooms and are available to support manual fire fighting inside the individual RHR pump rooms.~~

~~Considering the fire hazards in the area, the staff concludes that the applicant's proposed fire protection features for the RHR pumps provide an equivalent level of fire safety to Position D.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.9.5 Service Water Pumps~~

~~At elevation 741 ft 0 in. of the intake pumping station, the redundant essential raw cooling water (ERCW) pumps are separated by 3-hour fire-rated barriers. These pumps are also separated from the traveling screen pumps by 3-hour barriers; however, these barriers have open scuppers at the base of the wall of the ERCW pump rooms. The open scuppers in the fire barriers that separate the pumps from the traveling screens are a deviation and are discussed further in Section 6.6, "Deviation - Openings in Fire Barriers."~~

~~The ERCW pumps have no fire detectors. Hose stations from the ERCW strainer room and the screen wash pump room can be used for manual fire fighting in the ERCW pump rooms.~~

~~The staff concludes that the applicant's proposed fire protection features for the ERCW pumps provide an equivalent level of fire safety to Position D.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.10 Other Plant Areas~~

~~5.10.1 Hydrogen Piping~~

~~A 1-inch seismically designed hydrogen line is routed through the auxiliary building (AB) on elevation 713 ft 0 in. from the A15 wall to each unit's~~

~~volume control tank. Two isolation valves are installed in the hydrogen supply line outside the AB. These valves close automatically when the downstream flow rate reaches 50 standard cubic feet per minute (scfm). Any hydrogen leakage less than 50 scfm will be diffused and carried away by the AB ventilation system, keeping the hydrogen concentration in any given area below the lower explosive limit.~~

~~The staff concludes that the applicant's design criteria and bases for the hydrogen supply piping in the AB did not take any exceptions to Position D.2.b of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.~~

~~5.10.2 Askarel-Insulated Transformers~~

~~High-voltage high-amperage transformers are not installed within building spaces. Transformers installed within safety-related buildings are either the dry type or are insulated with a noncombustible liquid.~~

~~Transformers insulated with Askarel oil (a noncombustible insulating liquid) are located in various areas of the plant without being located in a separate room. Near these transformers are various redundant safety-related cable trays or conduits or both. The following locations contain these transformers: (1) intake structure, elevation 711 ft 0 in.; (2) auxiliary building, elevation 692 ft 0 in.; (3) east and west ends of the auxiliary building, elevation 772 ft 0 in.; (4) rooms A5, A6, and A12, auxiliary building, elevation 737 ft 0 in.; and (5) auxiliary building, elevation 737 ft 0 in. These transformers have relief valves to vent vapors generated by arcing within transformer housing.~~

~~The staff finds that the applicant's proposed use of transformers filled with noncombustible insulating liquid conforms to the guidelines of Position D.1.g of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.~~

~~6.0 DEVIATIONS FROM STAFF FIRE PROTECTION GUIDANCE~~

~~6.1 Deviation - Required Instrumentation for Alternative Shutdown~~

~~Section III.L.e.d of Appendix R requires the process monitoring function for the alternative shutdown to be capable of providing direct readings of the process variables necessary to perform and control a plant cooldown.~~

~~Contrary to these requirements, the applicant has not provided instrumentation in the auxiliary control room (ACR) for (1) tank level indication for the condensate storage tank (CST) and the refueling waters storage tank (RWST), (2) wide-range steam generator indication, and (3) cold-leg temperature indication. The justification for omitting this instrumentation is given below.~~

~~The CST level indication is not considered essential in the ACR because automatic switchover of the auxiliary feedwater pump suction from the CST to the service water system (SWS) header will be functional when control is established in the ACR.~~

~~The RWST level indication is not considered essential in the ACR because the RWST contains almost 20 times the inventory required for cold shutdown. The~~

~~RWST is primarily used as makeup for contraction resulting from cooldown over a period of hours.~~

~~Narrow-range steam generator level and auxiliary feedwater (AFW) flow indication to each generator are provided in the ACR in lieu of the wide-range steam generator level indication. This instrumentation provides input to the automatic control utilized to maintain steam generator level during plant shutdown during a fire. Although wide-range instrumentation is available in the main control room, no automatic control or safety system inputs are derived from this instrumentation. Using AFW flow indication, the operator is able to confirm adequate post-trip steam generator inventory should the level fall below the narrow range.~~

~~In the natural-circulation mode of operation, the difference between the hot- leg and cold-leg temperature ($T_h - T_c$) provides a direct indication of when the natural circulation is established and whether it is being maintained. The applicant proposes to monitor natural circulation by inferring T_{sat}, the saturation temperature corresponding to the secondary-side steam generator pressure, instead of using T_c. The applicant has stated that T_{sat} will accurately monitor natural circulation in the reactor coolant loop in the operating range from full power to the hot-standby condition. To demonstrate that T_{sat} will accurately monitor natural circulation in the operating range from hot standby to cold shutdown, the applicant analyzed the correlation between T_{sat} and T_c while a reactor is brought to the cold-shutdown condition.~~

~~The applicant bases its justification for its deviation in using the saturation temperature corresponding to the secondary-side steam generator pressure in place of T_c on the unique design of the ACR, the level of control and instrumentation available in the ACR and in the adjacent shutdown board rooms, Westinghouse Owners Group (WOG) recommendations, plant procedures and training on the ACR, and accuracy of T_{sat} to infer T_c.~~

~~In Revision 1 to its "Emergency Response Guidelines, Generic Issue on Natural Circulation," WOG offers specific guidelines on how an operator can verify that natural circulation has been established. WOG recommends the use of the following criteria for verifying natural circulation: (1) The RCS is subcooling (determining by converting of pressurizer pressure to T_{sat} and subtracting from T_h), (2) T_h is stable or decreasing, and (3) steam generator pressure is stable or decreasing. The instrumentation needed to use these methods of verifying natural circulation is available to the operator in the ACR.~~

~~Because the diversity in the design of the Watts Bar ACR provides other methods for verifying that natural circulation has either been established or lost, the staff concludes that the applicant has adequately justified not providing wide-range steam generator level and CST, RWST, and component cooling water surge tank water level indication on the ACR and that the applicant's request for a deviation from the requirements of Section III.L.e.d of Appendix R to 10 CFR Part 50 is acceptable.~~

~~6.2 Deviation - Noncombustible Radiant Energy Heat Shields~~

~~In Section III.G.2.f of Appendix R, the staff states that separating the trains by means of a noncombustible radiant energy shield is an acceptable way of ensuring that a redundant train of the systems located inside a noninerted~~

~~containment and that are necessary to ensure safe shutdown will be protected from damage from a fire.~~

~~SRP 9.5-1, Section B.4, defines noncombustible as "a material which in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapor when subjected to fire or heat." This definition was derived from the definition of non-combustible stated in NFPA-220 (1979), "Standard on Types of Building Construction." NFPA-220 identifies ASTM E-136, "Standard Method of Test for Non-combustibility of Elementary Materials," as a test method for determining the combustibility of a material.~~

~~The applicant is using Minnesota Mining and Manufacturing (3M) material M-20A in the secondary containment/annulus and M-20C in the primary containment. Using the ASTM E-136 test method, these materials do not satisfy the definition of noncombustible.~~

~~The applicant's radiant energy heat shield design in secondary containment uses four layers of M-20A on raceways (conduits, junction boxes, and penetration boxes) and two layers on the raceway supports and intervening items. Inside the primary containment, the radiant energy heat shields are constructed using three layers of M-20C on the raceway and two layers on the raceway supports and intervening items.~~

~~In order to evaluate the combustibility of the 3M materials, the applicant tested this material, gypsum board, and a known noncombustible material (marinite board) to ASTM E-162, "Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source," and ASTM E-1354, "Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter."~~

~~The ASTM E-162 test method is used for research and development purposes and gives a relative indication of a material's flame spread index when exposed to a known radiant heat energy source. This standard test method does not have an acceptance criterion. All three materials exhibited a very low flame spread index. The marinite board had a flame spread index of 0.1, gypsum board had a value of 0.9 and M20 material ranged from 0.9 to 1.2. By comparison, most typical building materials have a flame spread index which ranges from 0 to <100.~~

~~The ASTM E-1354 test method is used primarily to determine the heat evolved in, or contributed to, a fire involving products of the test material. This test method determines the effective heat of combustion, mass loss rate, and the time to sustain flaming and smoke production.~~

~~One of the principal properties determined by this test method is the rate of heat release by the material when exposed to an external heat flux of 75kW/m^2 with external electric spark ignition. Each of these materials were exposed to this external heat flux for 10 minutes. The peak heat release rate for marinite board was 11.6kW/m^2 and 27.1kW/m^2 for M20 material without the aluminum foil or a carbon steel exposed face. The total heat release for the marinite board was 31.1 kJ and 31.7 kJ for M20. The effective heat of combustion for both the marinite and the M20 was 7.2 MJ/kg. The applicant's test data for the M20-A (aluminum foil-faced material) M20-C (carbon steel- faced material) improved the thermal resistance performance of the M20~~

~~material when exposed to the ASTM E-1354 test conditions. For example, during its testing, the M20-A and M20-C did not ignite.~~

~~On the basis of the applicant's test data which demonstrate that the peak heat release rate, total heat release, and effective heat of combustion of M20 and marinite board are somewhat equivalent, and that the addition of an aluminum or a carbon steel face to M20 material improves its thermal resistance performance, the staff concludes that the use of M20-A and M20-C radiant energy heat shield designs inside containment provides an equivalent level of fire safety to that required by Section III.G.2.f of Appendix R and, therefore, is an acceptable deviation.~~

~~6.3 Deviation - Lack of Automatic Fire Suppression~~

~~Section III.G.3 of Appendix R requires that fixed fire suppression or fire detection be installed in the areas, rooms, or zones requiring alternative or dedicated shutdown capability.~~

~~The applicant requested a deviation from this Appendix R requirement for the following control building areas: (1) 250-V battery board room, (2) 24-48-V battery board room and charger room, (3) stairs, (4) corridor C2, (5) shower rooms, (6) main control room, (7) relay room, (8) corridor C15, (9) telephone room, and shop C20.~~

~~The purpose of providing fire detection and fixed fire suppression in an area containing normal shutdown equipment is to keep the fire from affecting alternative safe-shutdown capability. A fire in the Watts Bar control building could require the main control room to be abandoned and the plant to be shut down from the ACR. The control building is separated from the ACR and adjacent plant areas by 3-hour fire-rated barriers. Therefore, a fire in the control building is not expected to affect the ACR or the operator's ability to implement alternative shutdown from the ACR. The staff concludes that the lack of fire detection and fixed suppression in the control building areas identified above is an acceptable deviation from the requirements of Section III.G.3 of Appendix R to 10 CFR Part 50.~~

~~6.4 Deviation - Intervening Combustibles~~

~~Section III.G.2.b of Appendix R to 10 CFR Part 50 requires separation of redundant trains of safe-shutdown cables and equipment by a horizontal distance of more than 20 feet with no intervening combustibles. In addition to spatial separation, this section of Appendix R requires that automatic fire detection and suppression be installed in the area. The applicant requested a deviation from the restrictions of not allowing intervening combustibles in the 20-foot separation zone between redundant safe-shutdown trains. The primary combustibles between redundant safe-shutdown components are cables in open ladder-type trays.~~

~~The presence of these intervening combustibles is a concern because they add to the fire's intensity at the ceiling and they could serve as a path for fire propagation between the redundant safe-shutdown trains. The applicant bases its request on the automatic sprinkler system design in these areas. The applicant has provided sprinkler protection at the ceiling level in rooms containing redundant safe-shutdown components. To compensate for the presence of equipment and such structural obstructions as overlapping cable trays, HVAC~~

~~ducts, and pipes and supports, and provide full coverage at the ceiling, additional sprinkler heads have been incorporated into the design.~~

~~To mitigate the consequences of a floor-based fire, the applicant has provided additional sprinklers under intermediate obstructions for a path up to 30 feet wide between spatially separated redundant safe-shutdown trains that are not separated by intervening spaces that are free of combustibles.~~

~~The applicant has used the following design criterion as the basis for this deviation request:~~

- ~~Existing sprinkler heads, which have been located to produce fully developed spray patterns at the ceiling, will provide acceptable floor coverage if there are no intermediate obstructions in their patterns which are greater than 48-inch-wide. When individual obstructions overlap or have less than a 4-inch wide flue space between them when viewed from immediately below, they shall be considered a single obstruction for determining their cumulative horizontal width. No combination of obstructions may transverse the 4-inch flue space and block more than 2-feet of any 8-feet of the flue space.~~

~~Conforming to this criterion gives reasonable assurance that a fire would actuate the ceiling level sprinklers. These sprinklers would develop effective spray patterns at the ceiling, and the water would cascade down through the cable trays in the intervening space. The cooling effect of these sprinklers once actuated should help cool the layer of hot gas at the ceiling, and the sprinklers under the intermediate level obstructions should actuate to ensure that floor level coverage is provided.~~

~~In addition, the coverage provided by the ceiling sprinklers should produce sufficient cooling to reduce the likelihood that fire will propagate across the intervening space between the redundant trains. Therefore, considering the enhanced distribution of sprinklers in these intervening combustible spaces and the additional sprinklers provided under intermediate level obstructions, the staff concludes that the presence of intervening combustibles as fire hazards between redundant trains of safe-shutdown functions is adequately mitigated by the sprinkler design. Accordingly, the staff finds acceptablet the applicant's request to deviate from the requirements of Section III.G.2.b of Appendix R to 10 CFR Part 50.~~

~~6.5 Deviation - Partial Fire Wall Between Component Cooling Water System Pumps~~

~~The two Train A pumps are separated from the two Train B pumps and the spare pump by a 1-hour fire-rated fire barrier that extends 3 feet above the highest point of the pumps. Raceways containing the redundant circuits for the component cooling water system (CCWS) pumps are separated by 20 feet or more or by 1-hour fire-rated barriers. Train B control circuits routed in conduits located above or near the edge of the pump fire barrier are enclosed in a 1-hour raceway fire barrier systems. A ceiling-level preaction sprinkler system is provided for cable tray and general area coverage. Automatic sprinkler coverage has also been provided under the pipe-break barrier for the motor-driven auxiliary feedwater pumps and under the mezzanine for all five CCWS pumps. Cross-zoned ionization smoke detectors are provided to actuate the preaction suppression systems and give early warning of a fire.~~

~~To the extent that the partial-height wall does not completely isolate the redundant pumps, this configuration represents a deviation from Section III.G of Appendix R to 10 CFR Part 50. However, because of the fire detection system and automatic sprinkler system, the staff has reasonable assurance that any potential fire would be detected and suppressed before becoming a threat to the redundant pumps on the other side of the wall. Until the fire is suppressed, the partial-height wall will shield the pumps from radiant heat on one side and from fire on the other. Therefore, the partial-height wall is an acceptable deviation from the technical requirements of Section III.G of Appendix R to 10 CFR Part 50.~~

~~6.6 Deviation - Openings in Fire Barriers~~

~~Appendix A to BTP (APCSB) 9.5-1 specifies that penetrations in walls, floors, and ceiling forming part of a fire barrier be protected with seal-of-closure devices having a fire-resistive rating equivalent to that of the barrier.~~

~~The applicant identified the following fire barrier conditions at Watts Bar that deviate from this fire protection guidance: (1) the wall and floor to the ventilation and purge air (VPA) rooms are equivalent to 1-1/2-hour fire-rated barriers, but the postaccident sampling system (PASS) facility HVAC penetrations through these barriers do not have fire dampers; (2) the walls separating the essential raw cooling water (ERCW) pump rooms from the traveling screen room on elevation 741 ft 0 in. of the intake pumping station (IPS) are equivalent to 3-hour fire-rated barriers, but have unprotected scupper openings; and (3) floor slabs in the auxiliary building (AB) are used as zonal separation fire barriers between elevations, but have some HVAC penetrations that have no fire dampers, and stairwells and an equipment hatch that have water curtains in lieu of rated barriers.~~

~~In the VPAs, the walls and floor are penetrated by ducts associated with the PASS. These ducts have no fire dampers, but they also have no openings into the VPAs. All of these ducts are constructed from Schedule 40 carbon steel pipe. Pipe sleeves are provided where the ducts penetrate the barriers between the VPAs and the PASS and nitrogen storage rooms. The annular space between the sleeves and the pipes is sealed with a fire-rated silicone foam to a depth of 12 inches.~~

~~The only significant fire exposure to the ducts consists of two charcoal filter units. The ducts are separated from the nearest safe-shutdown circuit by a distance of 80 feet. Closed-head water-spray systems are provided in the charcoal filters and are actuated by duct-mounted ionization smoke detectors. The VPAs are provided with preaction sprinkler systems which are actuated by ionization smoke detectors. The PASS rooms (Units 1 and 2) have preaction sprinkler systems that are actuated by ionization smoke detectors. The nitrogen storage room has ionization smoke detection. Standpipe and hose systems and portable extinguishers also serve for manual fire fighting in these rooms.~~

~~The effect of a fire in the PASS or the nitrogen storage rooms could be experienced in the VPA in the form of radiant heat from hot gases passing through the ducts. In the VPA, no fixed combustibles are located in the immediate vicinity of these ducts, and the ducts and the nearest safe-shutdown circuit are separated by more than 20 feet. This provides a high degree of~~

~~assurance that radiant heat from the duct will not challenge the safe-shutdown components located in the VPA.~~

~~Because of the limited fire hazard, the available protection on either side of the duct penetrations of the VPA perimeter construction, and the construction of the ducts, the staff concludes that the ducts will remain in place until the fire is extinguished and that the absence of fire dampers will not lead to fire propagation from one fire area to another. Therefore, this duct configuration is an acceptable deviation from Section D.1.j of Appendix A to BTP (APCSB) 9.5-1 and Sections III.G.2.a and c of Appendix R to 10 CFR Part 50.~~

~~On elevation 741 ft 0 in. of the intake pumping station, the redundant ERCW pumps are separated by a 3-hour fire-rated barrier. These pumps are also separated from the traveling screen pumps by a 3-hour barrier; however, this barrier wall has an open scupper at its base in each ERCW pump room.~~

~~The scupper openings penetrating the fire wall between the ERCW pump rooms and traveling screen rooms are provided to drain rain water from the open pump rooms to the pump well. The floor deck at elevation 741 ft is sloped so that an oil spill from any one train of ERCW pumps does not have a direct route to the other train of pumps. The deck is sloped to the openings in the south wall (ERCW pump room side) so that a postulated oil spill will flow to the scupper passthrough, and immediately drop into the noncritical traveling screen wells in the traveling screen and screen wash pump room. The wall separating the ERCW pump rooms and traveling screen rooms is intended to protect the rooms from the radiant heat of an exposure fire. The roof of the intake pumping station deck is constructed of wide-flange beams to protect against missiles. However, the roof design permits free air flow between the beams so that, in the event of fire, heat will not stratify or bank down from the ceiling, thereby minimizing the temperature rise within the room.~~

~~The applicant found that this wall separating the ERCW pumps form the adjacent traveling screens and screen wash pump room is adequate to prevent the spread of fire. Therefore, this scupper configuration is an acceptable deviation from Position D.1.j of Appendix A to BTP APCSB 9.5-1 and Sections III.G.2.a and c of Appendix R to 10 CFR Part 50.~~

~~The auxiliary building is subdivided into individual fire zones on the basis of 1-1/2-hour fire-rated enclosures. However, the floor slabs within the building which form the boundary of some of these zones are not all fire rated. The floor itself is reinforced concrete that is equivalent to a 1-1/2-hour fire-rated barrier, except for equipment hatch openings, stairwells, unsealed spare conduit sleeves, and unprotected ventilation duct penetrations. The applicant has installed a water curtain designed in accordance with NFPA-13, Section 4-4.8.2, for (1) AB stairwells 5 and 6 openings located near column lines A11/S and A5/S, through floor slabs at elevation 713 ft 0 in. and 737 ft 0 in.; (2) the normally closed equipment hatch located at A13/S on elevation 772 ft 0 in.; (3) AB stairwell 3 openings located at column lines A8/U-V below floor elevations 713 ft 0 in. and 737 ft 0 in.; (4) equipment hatch openings located at column lines A8/V-W below floor elevations 713 ft 0 in., 737 ft 0 in., and 757 ft 0 in.; (5) equipment hatch opening located at column lines A3/S below floor elevation 772 ft 0 in.; and (6) the elevator door openings located at column lines A8/T below floor elevations 713 ft 0 in., 737 ft 0 in., and 757 ft 0 in.~~

~~Fire dampers with a 1-1/2-hour fire rating are installed in HVAC ducts located at column lines and elevations A6/S-713, A10-A22/S-713, and A5/R-737. No other equipment hatches, stairwells, or HVAC duct penetrations can expose redundant safe-shutdown equipment located on different floor elevations to damage from a single fire. For the remaining unprotected opening, the applicant has achieved compliance with Section III.G.2.b of Appendix R to 10 CFR Part 50 by providing more than 20 feet of cumulative horizontal separation between the redundant equipment and by providing areawide fire detection and automatic fire suppression.~~

~~The spare conduit sleeves consist of a section of rigid steel conduit embedded in the reinforced-concrete floor slabs. Both ends of the sleeves extend only a few inches from the floor slabs and are sealed with threaded conduit plugs.~~

~~The rooms containing the required safe-shutdown circuits that are separated from their redundant circuits by the floors with the conduit sleeves and plugs are protected by automatic fire detection and sprinkler systems. The actuation of the sprinkler systems during a fire will produce fully developed water spray patterns at the ceiling level. This will protect the sleeves from damage from a fire below and will reduce the temperature rise on the side not exposed to the fire. The staff, therefore, has reasonable assurance that the sleeves and plugs will prevent fire propagation into adjoining areas. The absence of continuous fire-rated construction at the above-referenced stairways, hatchways, and conduit sleeves is an acceptable deviation from the guidelines of Section D.1 of Appendix A to BTP (APCSB) 9.5-1.~~

~~The HVAC ducts associated with the waste gas system are constructed of spirally welded pipe and have no fire dampers where the pipes penetrate fire barriers. These penetrations are treated as normal pipe penetrations and have fire-rated seals.~~

~~The applicant requested a deviation from the guidelines of Section D.1.j of Appendix A to BTP (APCSB) 9.5-1 and Sections III.G.2(a) and (c) of Appendix R to 10 CFR Part 50 to the extent that they require the installation of fire dampers in waste gas system ducts that pass through fire barriers. The absence of these fire dampers in the waste gas system is acceptable because the applicant has complied with Section III.G.2.b of Appendix R to 10 CFR Part 50.~~

~~6.7 Deviation - Emergency Lighting~~

~~Section III.J of Appendix R to 10 CFR Part 50 requires that emergency lighting units with at least an 8-hour battery power supply be provided in all areas needed for operation of safe-shutdown equipment and in access and egress routes thereto. The applicant has requested a deviation from this emergency lighting requirement for the reactor building, turbine building, and the yard.~~

~~In the reactor building, valve manipulations require lighting. Twelve valves, four in the lower containment and eight in the annulus, may require manual action (open/closing); the earliest of these actions may take place within 2 hours of the fire event. The applicant claims that emergency lighting units cannot be qualified for high temperature and humidity environment inside the reactor building. In addition, the applicant claims that access to the reactor building during plant operations is very limited, which means that the battery units could only be inspected and tested during an outage. It is the applicant's position, that the use of portable lanterns provides a more~~

~~dependable source of light in the case of an Appendix R event and, therefore, conforms to the intended purpose of ensuring adequate lighting for an operator to perform a manual action.~~

~~The staff concluded that for access and egress to the sites within the reactor buildingat where manual action must be performed, the use of portable lanterns will not afford the same level of operator safety as fixed emergency lighting units. In addition, the staff does not agree that these lighting units are as dependable as fixed lighting units. The staff is concerned that when called on to perform, a portable lantern (due to the human element) is more likely to fail than a fixed lighting unit. For example, an operator may drop or damage a portable lantern while using it or transporting it in congested plant areas, rendering it inoperable. The staff, is also concerned that , in contrast to using a fixed emergency lighting unit, an operator may need to focus a portable light by manually manipulating it. This need for manual manipulation, coupled with lighting blackout conditions, may hinder the operator's ability to recognize equipment and complete the required manual action. Therefore, the staff finds unacceptable the applicant's request to deviate from the lighting criteria required by Section III.J of Appendix R to 10 CFR Part 50 inside the reactor building annulus and lower containment. The staff will track this issue to resolution by TAC M63648.~~

~~For fires in the auxiliary building involving the reactor coolant pump trip breakers, manual actions are required in the yard. The associated manual actions that require lighting in the yard are tripping the reactor coolant pump breakers located in the breaker switchhouse. Access to these breakers is through the transformer/switchyard. This area is provided with normal lighting and security lighting in the event normal lighting is lost. It is the applicant's position, that in the event normal lighting is lost and the security diesel lighting is unavailable (e.g., maintenance outage) dedicated portable lanterns would provide a dependable source of light for operator access and egress to the switchhouse. From its review, the staff would not expect a fire in the auxiliary building involving the reactor coolant pump trip breakers to cause a loss of normal yard lighting system or the diesel generator-powered security lighting system. Therefore, the staff finds acceptable the applicant's position to use dedicated portable lanterns to provide backup lighting to the normal yard and security lighting systems and to support operator access and egress to the switchhouse.~~

~~In the event of a fire that prevents access to the reactor trip switchgear (fire in fire areas 782.0-A1 and 757.0-A10), operators in the turbine building will normally need to manipulate breakers in order to ensure that the reactor is tripped. Normal lighting and standby lighting systems powered from an onsite emergency diesel generator will provide access lighting and lighting to support the required manual actions. A fire in auxiliary building fire areas 782.0-A1 and 757.0-A10 will not affect the power cables and the turbine building standby lighting feeder cables since these cables are not routed through these fire areas. Therefore, since the standby lighting system is not affected by the fire and is powered from an emergency diesel generator, the staff finds this alternative lighting method equivalent to the lighting criteria required by Section III.J of Appendix R to CFR Part 50.~~

~~For certain plant areas in which a postulated fire has occurred, the applicant's safe-shutdown analysis requires reentry into the area after the fire has been extinguished to perform certain manual actions (e.g., valve~~

~~manipulations). The applicant has provided emergency lighting for access and egress to these areas. The applicant's position is that installing emergency lighting units in the plant area affected by the fire could render them inoperable as a result of fire damage. Therefore, the applicant proposed to use dedicated portable lanterns in lieu of fixed lighting units to provide lighting support in these areas in which reentry into a fire-affected plant area (after the fire is extinguished) is necessary to perform manual plant actions. On the basis of its review, the staff concludes that portable lanterns provide a more dependable source of light than fixed emergency lighting units (which may be damaged by the fire) in those plant areas in which reentry into the fire-affected area is required to perform manual actions and, therefore, is an acceptable deviation to the lighting criteria required by Section III.J of Appendix R to 10 CFR Part 50.~~

~~6.8 Deviation - Lack of Total Area Suppression and Detection~~

~~Sections III.G.2.b and c of Appendix R to 10 CFR Part 50 require that automatic fire detection and suppression be installed in the areas of concern. To comply with these provisions, automatic suppression and detection sufficient to protect against the hazards of the area shall be provided. The applicant has provided partial suppression and detection to protect against fire hazards in the following areas: (1) RHR pump rooms and corridor 676.0-A1, (2) containment spray pump rooms, (2) AB pipe chase, (3) tunnel from AB to refueling water storage tank, (4) entrance labyrinth to the decon room, (5) centrifugal charging pump rooms, (6) boric acid transfer pump, tank, and filter areas, (7) 480-V board room 1BV and 2B (rooms 772.0-A2 and -A15), and (8) RHR heat exchanger rooms 1A and 1B.~~

~~The RHR pumps, their power cables, and the RHR room coolers are required for cold shutdown after a fire. Redundant pumps, cables, and coolers are separated by a combination of fire barriers (2-hour fire-rated pump cubicles and 1-hour fire-rated raceway barriers) and 20 feet of spatial separation without intervening combustibles. The rooms in which the pumps are located are provided with ionization smoke detectors but not with an automatic suppression system. The conduits in the corridor on AB elevation 676 ft 0 in. that contain both trains of RHR pump power cables are protected with 1-hour fire-rated barriers and are routed on opposite sides of the elevator shaft. This corridor does not have an automatic suppression system; however, automatic ionization detection is provided in this area. The exposed conduit on elevation 676 ft 0 in. which contains one train of RHR pump power cables is protected with a 3-hour fire-rated ERFBS where it is routed along the wall of the elevator shaft enclosure. The in situ fire load is low and is not in a configuration that would present a significant challenge to the protected power cable conduits. If a fire occurred in either an RHR pump cubicle or the corridor, the staff has reasonable assurance that the fire would be promptly detected by the fire detection devices in these areas and that the passive fire barriers would ensure that one train of cold-shutdown capability would remain undamaged until the plant fire brigade could control and extinguish the fire.~~

~~Each containment spray pump room is bounded by 2-hour fire-rated barriers and the rooms have automatic fire detection but do not have an automatic suppression system. Each pump room contains the pump and its associated power cable and room cooler. Each containment spray pump is identified as a potentially spuriously operating component which is prevented from starting in~~

~~the event of a fire in the room. The combustible load in these rooms is low and the configuration of the in situ combustibles is arranged so that a fire in this room would not achieve a severity which would challenge the fire rating of the 2-hour fire-rated boundaries. On the basis of low combustible loads in these rooms, the fire rating of the fire barriers that bound these rooms, in combination with automatic fire detection (except in the entrance labyrinth), it is not expected that a fire inside one of the containment spray pump rooms would propagate to adjacent plant areas; therefore, the staff has reasonable assurance that the fire would be promptly detected by the fire detection devices in these areas and that the passive fire barriers would ensure that the plant's ability to achieve and maintain post-fire safe-shutdown condition would remain undamaged until the plant fire brigade could control and extinguish the fire.~~

~~The AB pipe chase extends from elevation 676 ft 0 in. to 757 ft 0 in. The pipe chase is enclosed by a reinforced-concrete construction and has a fire rating of 1 hour. There are minimal combustibles in the chase itself. The applicant has provided automatic ionization smoke detection inside the chase. Routed inside the chase are one train of the cabling, the level transmitter associated with the volume control tank, and the cabling associated with wide- range level indication for two steam generators. The redundant instrumentation associated with VCT level and steam generator wide-range level is located outside the pipe chase in an area that has automatic suppression. Located inside this chase are the RHR mini-flow valves which have containment spray suction valves and are required only if a fire causes the spurious operation of RHR or containment spray pumps. The cable associated with these pumps, which, if exposed to fire, could cause their spurious operation, is located outside the pipe chase in a plant area that is protected by automatic suppression. Therefore, if a fire occurred inside the pipe chase, the staff has reasonable assurance that the fire would be promptly detected by the fire detection devices in these areas and the passive fire barrier around the chase would ensure that the one train of shutdown capability outside the chase would remain undamaged until the plant fire brigade could control and extinguish the fire.~~

~~The RWST tunnel is an underground tunnel of reinforced concrete. One end of the tunnel opens into the AB on elevation 692 ft 0 in. and the other end is accessed via a manhole located in the yard near the RWST. The tunnel does not have automatic fire and smoke detection or suppression capabilities. Fire detection and automatic sprinklers are provided on elevation 692 ft 0 in. of the AB, protecting the entrance to the tunnel from an AB-related exposure fire. RWST level transmitter circuits are routed through the tunnel in conduits. These circuits are required for shutdown only if the fire causes the RHR or the containment spray pumps to activate spuriously or the containment sump valves to open. A fire originating in the tunnel cannot cause spurious signals to actuate this equipment. Therefore, if a fire occurred inside the tunnel, the staff has reasonable assurance that the fire would not affect the plant's ability to achieve and maintain safe shutdown and that the automatic fire suppression system on AB elevation 692 ft 0 in. would prevent fire from spreading into the AB. In addition, the automatic fire detection capability on AB elevation 692 ft 0 in. would detect the tunnel fire, and the plant fire brigade would respond to assist in controlling and suppressing the fire.~~

~~The decon room (room 692.0-A18) is provided with fire detection and automatic suppression; however, the suppression system does not extend into the entrance labyrinth. The decon room contains one train of safe-shutdown cabling and this cabling is not located in the entrance labyrinth. The decon room and its labyrinth is bounded by fire barriers having a 2-hour fire rating. The in situ combustible load is low; this area is a radiologically controlled area and its access is administratively controlled. In the event that a fire did occur in the room's labyrinth, it would be detected by the decon room's automatic fire detection system and the automatic sprinklers would prevent the fire from propagating into the decon room. Considering the fire protection features provided for the decon room, the staff has reasonable assurance that a fire in the decon entrance labyrinth would be detected and controlled by the room's automatic sprinkler system until the fire brigade could respond and extinguish the fire and, therefore, the staff finds acceptable the current level of fire safety provided for the decon room and its entrance labyrinth.~~

~~In the centrifugal charging pump rooms, the sprinkler system protects the safe-shutdown systems but does not extend to an entrance labyrinth, on AB elevation 713 ft 0 in., the general floor area is provided with automatic suppression except for the boric acid transfer pump, tank, and filter areas (column lines A11-A14/Q-S). In the 480-V board rooms 1BV and 2B, the sprinkler system does not extend over the portion of the room that contains one set of vital battery inverters and chargers (column lines A6-8/Q-R and A8-10/Q-R). This set may be damaged by water from the sprinkler heads. A fire in any of these locations would be detected by the existing fire detection system before propagating significantly. If the fire propagated rapidly before the brigade arrived, individual sprinklers in the protected portion of the area would operate to limit the spread of fire and to protect the shutdown-related systems until the fire was controlled and suppressed by the plant fire brigade. In either event, the staff has reasonable assurance that a safe-shutdown capability would remain undamaged.~~

~~The RHR heat exchanger room 1A and 1B (rooms 713.0-A11 and 713.0-A12) are separated from each other and from other areas of the plant by 2-hour fire- rated barriers. These areas do not have automatic fire detection or suppression systems. Each RHR heat exchanger is a passive safe-shutdown component. The combustible load in these rooms is low and a fire in either of these rooms would not damage the heat exchanger or its associated valves. On the basis of the passive fire protection features in the RHR heat exchanger rooms, low combustible loading, and the administrative radiological controls that restrict access to these rooms, the staff has reasonable assurance that a fire in either of these rooms would not damage the passive RHR system components; therefore, the staff finds acceptable the current level of fire safety provided for the RHR heat exchanger rooms.~~

~~The staff concludes that the partial coverage of the automatic suppression and detection in these plant areas is sufficient to protect against the fire hazards in these area and that this level of protection provides an equivalent level of fire safety to that required by Sections III.G.2.b and c of Appendix R to 10 CFR Part 50 and, therefore, is acceptable.~~

~~The remaining locations identified in the applicant's September 28, 1995, Fire Protection Report (Part VII, "Deviations and Evaluations"; Section 3.1, "Lack of Total Area Suppression and Detection") have no sprinkler/water-spray protection because they contain no safety-related or shutdown-related systems~~

~~and because the fire hazard is minimal. Combustible materials are dispersed so that any postulated fire would be of limited magnitude and duration. A fire, would be detected by existing automatic fire detection systems in these locations or in adjoining rooms within the overall fire area. The fire would be suppressed by the fire brigade using manual fire-fighting equipment. Because these locations have no shutdown systems, fire damage in them will have no effect on the ability to achieve and maintain safe shutdown. Therefore, the staff concludes that the lack of automatic fire suppression capability in plant areas identified in the applicant's Fire Protection Report (Part VII, Section 3.1) is an acceptable deviation to Section III.G.2.b of Appendix R to 10 CFR Part 50.~~

~~6.9 Deviations - BTP 9.5-1, Appendix A~~

~~6.9.1 Automatic Detection in Refueling Room - 757.0-A13~~

~~Position F.13 of Appendix A to BTP (APCSB) 9.5-1 specifies that automatic fire detectors should be installed in the area of spent fuel pools. The refueling room (room 757.0-A13) has no automatic fire detection system.~~

~~The applicant justifies its requested deviation from the fire protection guidance provided in Appendix A on the bases that this plant area is a large open area (16,000 ft^2) with a high ceiling (approximately 55 feet above the floor), and that during normal operations, the in situ combustible loading in this room is insignificant.~~

~~During its July 1995 site visit, the staff reviewed this area of the plant. On the basis of this site visit, the staff concurs that the installation of early-warning smoke detectors on the ceiling of this plant area would not improve the overall fire safety of this plant area. After reviewing this area, it is the staff's judgment that, because of the high ceiling, this area could potentially be susceptible to smoke stratification. Therefore, a fire in this area would not have sufficient energy to create the necessary air currents to carry the smoke to the ceiling; thus, smoke detectors at the ceiling level would not be reliable to provide early detection of a fire.~~

~~In this area, the associated fire risk is higher when the plant is in the refueling mode and, generally, this area would be manned throughout these operations. In addition, if a fire where to occur in this area while the plant is operating, the capability to safely shut down the reactor would not be affected. Therefore, considering the configuration of the refueling room and that a fire in this area would not affect the plant's ability to achieve safe shutdown, the staff finds acceptable the applicant's request to not provide automatic fire detection in the refueling room.~~

~~6.9.2 Fire Doors~~

~~Position D.1.j in Appendix A to BTP (APCSB) 9.5-1, recommends that door openings be protected with equivalently rated fire doors, frames, and hardware that have been tested and approved by a nationally recognized laboratory. A number of the fire doors at Watts Bar have been altered by the addition of signs and security hardware or have been damaged and repaired.~~

~~Fire doors in most of the fire zone and fire area boundaries are UL labeled. The special-purpose doors in the auxiliary building, such as flood doors and~~

~~pressure doors, are not UL labeled. These doors are designed to ASME standards and are of heavily welded steel construction. The applicant has evaluated these doors and determined that they will provide a fire rating commensurate to the fire loading in the areas or zones they separate. The security doors in the main control room are not UL labeled. They are made of bullet-resistant, heavy-gauge steel, and the door manufacturer has certified that the doors are equivalent to UL-tested 3-hour fire-rated doors. The applicant considers these untested doors equivalent to UL-tested doors. Similar doors were found acceptable for the Sequoyah nuclear plant. Therefore, the staff finds these doors acceptable.~~

~~The staff evaluated the unlisted special-purpose fire doors. The applicant submitted the results of an independent UL evaluation of fire doors in the plant. In its report, UL recommended a number of modifications to certain doors to ensure the performance of the doors during a fire. The applicant has addressed the following general recommendations of UL:~~

~~(1) Installing signs on fire doors is a minor modification which will not change the fire rating of the doors.~~

~~(2) Gasketing material is approved for use on fire doors.~~

~~(3) Conduit penetrations into the door frame are anchored either in accordance with UL recommendations or are continuously welded to the door frames.~~

~~(4) Small holes (3/16-inch diameter or smaller) in fire doors and frames have been repaired by slightly dimpling the hole, welding it completely closed, and grinding it smooth, or by installing self-sealing rivets or steel pan-head self-tapping sheet metal screws to seal the hole closed. Holes 3/16 inch to 2 inches in diameter or rectangular holes with the longest side less than 1-1/2 inches can be repaired by welding a 16-gauge steel plate overlapping the edge of the hole by a minimum of 3/4 inch.~~

~~(5) Fire door hardware is UL listed or Factory Mutual (FM) approved.~~

~~(6) All plant fire doors, except A188 (fire door between mechanical equipment room and 480-V shutdown board room 2A), C49, and C50 (fire doors between the main control room and 480-V shutdown board room 1B) are adjusted to ensure the gap between the door and the frame is 3/16 inch or less.~~

~~(7) Labeled fire doors and frames that are missing labels have been evaluated as providing equivalent protection to labeled doors.~~

~~Where the applicant has modified the doors according to the UL recommendations, the staff considers these doors to be in accordance with the guidelines in Section D.1.j of Appendix A to BTP (APCSB) 9.5-1 and, therefore, acceptable. The applicant does not intend to remove plastic and metal signs on certain doors as recommended. UL was concerned that these signs might ignite on the side that was not exposed to a fire and cause further fire spread. The staff observed these signs during its sign audits and concludes that, because of their limited size, they do not represent a significant fire hazard. In addition, the existing fire protection and the clear area around the doors give the staff reasonable assurance that if the signs ignite during~~

~~a fire, the fire would not propagate. Therefore, the placement of these plastic signs on the doors is acceptable.~~

~~The applicant provided justification as to why the doors A188, C49, and C50 should not be modified according to UL recommendations. The modifications pertain to reducing the existing 3/8-inch gap between the door and its frame so as not to exceed the maximum allowable clearances as stipulated in Paragraph 2-5.4 of NFPA-80. UL was concerned that the gap would result in fire propagation through the door. However, except for the constantly manned main control room, the rooms on both sides of these doors are protected by complete fire detection and automatic fire suppression systems. The staff, therefore, has reasonable assurance that any fire would be detected in its initial stages before a significant fire developed and would be suppressed quickly by the automatic systems or manually by the control room operators or fire brigade. Because of the gaps, a small amount of smoke and hot gases would be expected to pass through the opening, but because of the existing level of protection and the expected early fire control, the staff does not consider this to represent a significant hazard. Therefore, the unmodified doors referenced above are an unacceptable deviation from Position D.1.j of Appendix A to BTP (APCSB) 9.5-1.~~

~~6.9.3 Openings in Fire Walls~~

~~Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 specifies that penetrations in fire barriers be sealed or closed to provide a fire resistance rating at least equal to that of the barrier itself. The applicant requested a deviation from this position for a 6-inch-wide by 3-inch-deep gutter which penetrates two stairwell enclosures (stair C1 and C2) on control building elevation 692 ft 0 in. These two stairwells are located at the opposite ends of the corridor, (approximately 70 feet apart). The gutter penetrates the walls separating the stairwells from the corridor. Floor drains, one in each stairwell and two in the corridor, are located in this gutter. The only in situ combustible liquids (35 gallons) in the area of the corridor are associated with the electrical board room chiller packages located in the mechanical equipment room. This room is separated from stairwell C2 by a 3-hour fire-rated barrier. The corridor has a preaction sprinkler system that is actuated by an ionization detection system.~~

~~A fire would be detected by existing automatic fire detection systems in the corridor. The sprinkler in the corridor would control the fire in the corridor and limit the fire spread. The fire would be suppressed by the fire brigade using manual fire-fighting equipment. Because these locations do not contain shutdown systems, fire damage in them will have no effect on the ability to achieve and maintain safe shutdown. Therefore, the staff concludes that the applicant's request for a deviation from Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 for the gutters that penetrate stairwells C2 and C3 on control building elevation 692 ft 0 in. is acceptable.~~

~~6.9.4 Manual Hose Stations~~

~~Position D.3.d of Appendix A to BTP (APCSB) 9.5-1 specifies that interior manual hose stations be able to reach any location with at least one effective hose stream. This requirement should be satisfied by providing standpipes thoughout the plant equipped with hose stations that have a maximum of 75 feet of 1-1/2-inch fire hose and a suitable fire-fighting nozzle. The applicant~~

~~requests a deviation from this guidance because manual hose stations with 100 feet of fire hose are located throughout the Watts Bar facility and because some hose stations have more than 100 feet of hose. The hose stations that have more than 100 feet of hose are (1) station 0-26-1077, diesel generator building, elevation 742 ft 0 in.; (2) station 0-26-1188, control building, elevation 708 ft 0 in., (3) station 0-26-1193, control building, elevation 708 ft 0 in., (4) station 1-26-664, auxiliary building, elevation 772 ft 0 in., (5) station 2-26-664, auxiliary building, elevation 772 ft 0 in., (6) station 1-26-665, auxiliary building, elevation 757 ft 0 in., and (7) station 2-26-665, auxiliary building, elevation 757 ft 0 in.~~

~~The standpipe and hose stations at Watts Bar are designed to meet NFPA-14, which would allow up to 100 feet of fire hose at each hose station. In addition, the applicant took care during design to place hose stations in plant areas that support their accessibility and deployment. The staff concludes that the applicant's hose station layout, using hose lines of 100 feet in lieu of 75 feet and, in the special cases, using hose lines more than 100 feet (noted above) will ensure an effective hose stream to all plant areas and, therefore, is an acceptable deviation from staff fire protection guidance.~~

~~6.9.5 Fire Barrier Penetration Between Fuel Oil Transfer Pump Room and the Diesel Generator Building Corridor.~~

~~Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 specifies that penetrations in fire barriers should be sealed or closed to provide a fire resistance rating at least equal to that of the barrier itself. The applicant requested a deviation from this position for a penetration (a control panel steel box) in a 2-hour fire-rated barrier which separates the fuel oil transfer pump room from the diesel generator building corridor. This penetration is not a tested configuration. The fire barrier separating the fuel oil transfer pumps from the diesel generator corridor is constructed of 8-inch-thick reinforced- concrete block (fire rated for 2 hours). The non-fire-rated opening in this wall is 41 inches by 24 inches and contains a steel control panel box. The annular gap between the box and the wall is filled with concrete grout. The back of this box is flush with the surface of the wall inside the fuel transfer pump room, and the front of the panel is flush with the outside wall on the diesel generator corridor side.~~

~~The fuel oil transfer pump room has an automatic detection system and a total flooding~~ $\cancel{CO_2}$ ~~suppression system. The corridor has an automatic detection and sprinkler system. These detection systems are alarmed and annunciated in the main control room. Upon receipt of a detection alarm (both detection zones in a given plant area), the control room notifies/alerts the site fire brigade.~~

~~If a fire were to occur in the fuel oil transfer pump room that was not controlled by either the automatic fire suppression system or the plant fire brigade, the applicant claims that the fire would not challenge the ability of the box to prevent the passage of flame and hot gases from one side of the barrier to the other. The applicant bases its claims on observations of 3-hour fire tests of penetrations that contained pipes (30 inches to 2 inches) with similar thickness of steel plate welded on the end of the pipe placed in the test furnace and observation that this single steel plate during the test did not allow the passage of flame. The applicant concludes that this box~~

~~configuration with two layers of steel plate separated by an air gap would perform as well.~~

~~On the basis of its review of this penetration configuration and the associated fire protection features in the areas of concern, the staff finds that this non-fire-rated steel box configuration installed in the 2-hour fire-rated barrier separating the fuel oil transfer pump room from the diesel generator corridor is adequate to prevent the passage of flame from one of these plant areas to the other and, therefore, this is an acceptable deviation from Position D.1.j of Appendix A to BTP (APCSB) 9.5-1.~~

~~6.9.6 Large Fire Dampers~~

~~Fire dampers 1-ISD-31-3807 and 2-ISD-31-3882 are installed in wall openings that measure approximately 100 inches by 25 inches. These dampers measure approximately 98 inches by 24-1/2 inches and deviate from the maximum damper size shown on the vendor's drawing.~~

~~Fire test reports dated June 15 and July 19, 1984, document the results of tests conducted by Underwriters Laboratories (UL) for Ruskin on large-size fire damper installations. These large fire damper configurations (100 inches by 91 inches and 100 inches by 72 inches) passed the 3-hour fire endurance acceptance criteria by remaining in place and preventing the passage of fire; however, they failed the hose stream test. The applicant asked UL to evaluate the installation for dampers 1-ISD-31-3807 and 2-ISD-31-3882 and, in a report dated December 12, 1984, UL stated that, "It is judged that the reduction in size from 100 by 91 in. to 100 by 36 in. would significantly minimize the buckling and twisting of the vertical mullions noted in the June 15, 1984 Report." UL also stated that the maximum size of dampers covered by the UL classification and followup service program is 90 inches wide by 72 inches high in multiple assemblies (maximum assembly sections being 30 inches wide by 36 inches high) and that dampers exceeding these dimensions are not eligible to be labeled.~~

~~These large fire damper installations at Watts Bar are (1) constructed from individual damper sections which are smaller than the maximum allowed by UL; (2) the UL-listed assembly is three sections wide by two sections high, but the Watts Bar configuration is only one section high, thus making the assembly more rigid and less susceptible to buckling and twisting under actual fire conditions; and (3) the test assemblies were subjected to a 3-hour fire test. The Watts Bar installations are only required to resist fire for 2 hours; thus, the reduction in fire exposure would also increase the confidence that these dampers can perform their intended function. On the basis of its review of the fire hazards in the area of these specific Watts Bar fire damper installations, the staff concludes that these fire dampers will adequately prevent the spread of fire and, therefore, they are acceptable.~~

7.0 CONCLUSION

On the basis of its review of the applicant's Fire Protection Report through Revision 4 and the applicant's supplemental information as referenced by this safety evaluation, the staff concludes that the fire protection program for Watts Bar Nuclear Plant conforms to the requirements of 10 CFR 50.48 ~~and, except for (1) the fire barrier penetration seal program (refer to Section 3.1.4, "Fire Barrier Penetration Seals"; and (2) emergency lighting inside the~~ U1

~~reactor building (refer to Section 6.7, "Deviation - Emergency Lighting"), is acceptable.~~

TABLE 1

PHASE 1 - CONDUIT AND JUNCTION BOX TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 1-1 REPORT NO.: 11210-94554c TEST DATE: 12/21/92	THERMAL PERFORMANCE CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 65EF MAX. AVG. TEMP. = 315EF MAX. SINGLE POINT TEMP. = 390EF FIRE RATING PERIOD: 1-HOUR				BARRIER CONDITION		REMARKS
	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
	AVG	MAX	AVG	MAX			
5" DIA. STEEL CONDUIT (5/8" BASE W/MESH/TROWEL-GRADE)	242	297	297	469 (NOTE 1)			
5" DIA. STEEL CONDUIT (5/8" BASE)	255	343	253	316			
1" DIA. STEEL CONDUIT (5/8" BASE W/MESH/TROWEL-GRADE)	817	1656	523	781			
1" DIA. STEEL CONDUIT (5/8" BASE)	642	1312	476	612			
2" DIA. AIR-DROP (5/8" BASE W/MESH/TROWEL-GRADE)	612	842	622	845			
2" DIA. AIR-DROP (5/8" BASE)	419	467	481	649			
TEST ASSEMBLY 1-2 REPORT NO. 11210-94554a TEST DATE: 1/7/93	CONDITIONS OF ACCEPTANCE INITIAL TEMPERATURE = 61EF MAX. AVG. TEMP. = 311EF MAX. SINGLE POINT TEMP. = 386EF FIRE RATING PERIOD: 1-HOUR				BARRIER CONDITION		
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		UNSAT	SAT	
5" STEEL CONDUIT (5/8" BASE W/MESH/TROWEL-GRADE)			AVG 203	MAX 211		SAT	EXTERIOR CONDUIT SURFACE TEMPERATURE NOT RECORDED
5" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)			178	197		SAT	THERMOCOUPLE PLACEMENT DID NOT FOLLOW NRC POSITION
1" STEEL CONDUIT (5/8" BASE W/MESH/TROWEL-GRADE)			232	265		SAT	TEST DATA COLLECTED FOR ENGINEERING PURPOSES ONLY
1" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)			213	225		SAT	
2" DIA. AIR-DROP (5/8" BASE W/MESH/TROWEL-GRADE)			210	213		SAT	
2" DIA. AIR-DROP (5/8" BASE WITH 3/8" OVERLAY)			208	211		SAT	

Note 1 - The thermocouples located on the 8 AWG bare copper conductor inside each of the conduit and air-drop test specimens were subject to moisture saturation. This caused artificially high temperature readings. These temperature readings were not considered accurate.

TABLE 1 - CONTINUED
PHASE 1 - CONDUIT AND JUNCTION BOX TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 1-3	THERMAL PERFORMANCE				BARRIER CONDITION		REMARKS
REPORT NO.: 11210-94554a TEST DATE: 3/31/93	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 76EF MAX. AVG. TEMP. = 326EF MAX. SINGLE POINT TEMP. = 401EF FIRE RATING PERIOD: 1-HOUR				UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR				
	AVG	MAX	AVG	MAX			
1" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)	228	252	223	238		SAT	ALL TEST SPECIMENS MET THE TEST ACCEPTANCE CRITERIA.
2" STEEL CONDUIT (3/8" BASE WITH 3/8" OVERLAY)	224	246	219	229		SAT	
3" STEEL CONDUIT (3/8" BASE WITH 3/8" OVERLAY)	219	238	214	224		SAT	
4" STEEL CONDUIT (5/8" BASELINE)	276	365	258	342		SAT	
TEST ASSEMBLY 1-4	CONDITIONS OF ACCEPTANCE				BARRIER CONDITION		
REPORT NO. 11210-94554b TEST DATE: 4/1/93	INITIAL TEMPERATURE = 75EF MAX. AVG. TEMP. = 325EF MAX. SINGLE POINT TEMP. = 400EF FIRE RATING PERIOD: 1-HOUR						
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		UNSAT	SAT	
	AVG	MAX	AVG	MAX			
3" STEEL CONDUIT	349	407	327	380		SAT	SEE NOTE 2
1-1/2" STEEL CONDUIT (3/8" BASE WITH 3/8" OVERLAY)	284	330	269	307		SAT	THE 1-1/2 STEEL CONDUIT TEST SPECIMEN MET THE TEST ACCEPTANCE CRITERIA.
3" ALUMINUM CONDUIT	355	445	332	407		SAT	

Note 2 - Both the 3-inch-diameter steel conduit and the 3-inch-diameter aluminum conduits exceeded the maximum allowable temperature limits of the test acceptance criteria. The 3-inch-diameter steel conduit exceeded the maximum allowable average temperature criteria at 56 minutes and exceeded the maximum individual thermocouple temperature rise criteria at 59 minutes. The 3-inch-diameter aluminum conduit exceeded both the maximum allowable average temperature criteria and the individual thermocouple temperature rise criteria in 53 minutes.

TABLE 1 - CONTINUED
PHASE 1 - CONDUIT AND JUNCTION BOX TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 1-5	THERMAL PERFORMANCE						BARRIER CONDITION		REMARKS
REPORT NO.: 11210-94554d TEST DATE: 4/6/93	CONDITIONS OF ACCEPTANCE (BF) INITIAL TEMPERATURE = 73BF MAX. AVG. TEMP. = 323BF MAX. SINGLE POINT TEMP. = 398BF FIRE RATING PERIOD: 1-HOUR						UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		JUNCTION BOX SURFACE				
	AVG	MAX	AVG	MAX	AVG	MAX			
1" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)	218	223	212	219				SAT	ALL TEST SPECIMENS MET THE TEST ACCEPTANCE CRITERIA.
3" STEEL CONDUIT (3/8" BASE WITH 3/8" OVERLAY)	262	299	228	246				SAT	
2" STEEL CONDUIT (3/8" BASE WITH 3/8" OVERLAY)	220	243	213	223				SAT	
6" STEEL CONDUIT (5/8" BASE)	256	280	225	243				SAT	
6"x 6"x 6" STEEL JUNCTION BOX					206	208		SAT	
18"x 12"x 8" STEEL JUNCTION BOX					221	248		SAT	
12"x 12"x 8" STEEL JUNCTION BOX					228	264		SAT	
20"x 12"x 12" STEEL JUNCTION BOX					214	220		SAT	
24"x 18"x 12" STEEL JUNCTION BOX					239	294		SAT	
TEST ASSEMBLY 1-6 REPORT NO. 11210-94554e TEST DATE: 4/7/93	CONDITIONS OF ACCEPTANCE INITIAL TEMPERATURE = 72BF MAX. AVG. TEMP. = 322BF MAX. SINGLE POINT TEMP. = 397BF FIRE RATING PERIOD: 1-HOUR						BARRIER CONDITION		
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		JUNCTION BOX SURFACE		UNSAT	SAT	
	AVG	MAX	AVG	MAX	AVG	MAX			
4" STEEL CONDUIT - 5/8" BASE	271	322	219	287				SAT	ALL TEST SPECIMENS MET THE TEST ACCEPTANCE CRITERIA.
4" STEEL CONDUIT - 5/8" BASE	261	316	215	285				SAT	
4" STEEL CONDUIT - 5/8" BASE	275	338	227	294				SAT	
48"x 36"x 12" STEEL JUNCTION BOX					186	206		SAT	

TABLE 2
PHASE 2 - CABLE TRAY AND UNIQUE CONFIGURATION TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 2-1 REPORT NO.: 11960-97185 TEST DATE: 09/07/94	THERMAL PERFORMANCE												BARRIER CONDITION		REMARKS
	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 83 EF MAX. AVG. TEMP. = 333 EF MAX. SINGLE POINT TEMP. = 408 EF FIRE RATING PERIOD: 1-HOUR												UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	LEFT RAIL		RIGHT RAIL		TOP OF CABLES (NOTE 1)		BELOW RUNGS (NOTES 2 & 3)		CONDUIT SURFACE		INSIDE CONDUIT				
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
18" WIDE STEEL CABLE TRAY (0% CABLE FILL)	30 6	349	290	358			346	370					UNSAT		EXCEEDED AVG TEMP ON TOP OF RUNGS
18" WIDE STEEL CABLE TRAY (6.24 LBS/FT CABLE FILL)	280	328	273	319	289	305	285	314						SAT	
18" WIDE STEEL CABLE TRAY (69.36 LBS/FT CABLE FILL)	207	212	218	238	224	261	231	272						SAT	
3" DIA. STEEL CONDUIT									214	273	195	237		SAT	

TEST ASSEMBLY 2-2 REPORT NO. 11960-97186 TEST DATE: 09/08/94	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 82 EF MAX. AVG. TEMPERATURE = 332 EF MAX. SINGLE POINT TEMPERATURE = 402 EF FIRE RATING PERIOD: 1-HOUR														BARRIER CONDITION		
SPECIMENS	FRONT RAIL		REAR RAIL		RIGHT RAIL		LEFT RAIL		ON RUNGS (NOTE 3)		ON RUNGS LEFT SIDE		ON RUNGS RIGHT SIDE		UNSAT	SAT	
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
SPECIAL DOUBLE CROSS CABLE TRAY FITTING	246	262	237	249	263	267	265	271			286	301	284	305		SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA
FRONT 18" STEEL CABLE TRAY	236	246	271	292					288	308						SAT	
BACK 18" STEEL CABLE TRAY	276	298	248	258					291	321						SAT	

TABLE 2 - CONTINUED
PHASE 2 - CABLE TRAY AND UNIQUE CONFIGURATION TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 2-3 REPORT NO.: 11960-97187 TEST DATE: 09/20/94 SPECIMENS	THERMAL PERFORMANCE CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 78 EF MAX. AVG. TEMPERATURE = 328 EF MAX. SINGLE POINT TEMPERATURE = 403 EF FIRE RATING PERIOD: 1-HOUR										BARRIER CONDITION		REMARKS
	FRONT TRAY SIDE RAIL		REAR TRAY SIDE RAIL		BELOW RUNGS		ON RUNGS		INSIDE AIR DROP		UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
COMMON ENCLOSURE (3-18" CABLE TRAYS) A. TOP TRAY B. MIDDLE TRAY C. BOTTOM TRAY	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX		SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA
	264	301	277	318			272	344					
	265	321	263	343			271	343					
	258	331	255	330									
18" STEEL CABLE TRAY WITH RAISED STEEL COVER	225	268	218	241	229	285						SAT	
1" DIAMETER AIR DROP									206	214		SAT	
5" DIAMETER AIR DROP									182	199		SAT	

TEST ASSEMBLY 2-4 REPORT NO. 11960-97257 TEST DATE: 11/17/94 SPECIMENS	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 78 EF MAX. AVG. TEMPERATURE = 328 EF MAX. SINGLE POINT TEMP. = 403 EF FIRE RATING PERIOD: 1-HOUR														BARRIER CONDITION		
	ENCLOSURE UNISTRUT FRAME		LOWER REAR CONDUIT		UPPER REAR CONDUIT		LOWER FRONT CONDUIT		UPPER FRONT CONDUIT		FRONT CONDUIT		REAR CONDUIT		UNSAT	SAT	
TWO-SIDED ENCLOSURE (8-4" STEEL CONDUITS)	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX		SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA
	223	284	142	188	142	180	132	176	129	166							
TWO-SIDED ENCLOSURE (2-1" STEEL CONDUITS)	192	218									143	164	135	152		SAT	

TABLE 2 - CONTINUED
PHASE 2 - CABLE TRAY AND UNIQUE CONFIGURATION TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 2-5	THERMAL PERFORMANCE										BARRIER CONDITION		REMARKS
REPORT NO.: 11960-97258 TEST DATE: 10/27/94	CONDITIONS OF ACCEPTANCE (ßF) INITIAL TEMPERATURE = 62 ßF MAX. AVG. TEMPERATURE = 312 ßF MAX. SINGLE POINT TEMPERATURE = 387 ßF FIRE RATING PERIOD: 1-HOUR										UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	TOP CONDUIT		MIDDLE CONDUIT		BOTTOM CONDUIT		JUNCTION BOX INTERNAL SURFACE						
STEEL JUNCTION BOX (60"x 36"x 24")	AVG	MAX	AVG	MAX	AVG	MAX	AVG 200	MAX 223				SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA.
THREE-SIDED ENCLOSURE (3-PARALLEL 3" DIAMETER ALUMINUM CONDUITS)	148	171	149	168	156	187						SAT	
THREE-SIDED ENCLOSURE (2-PARALLEL 1" DIAMETER STEEL CONDUITS)	180	186			173	182						SAT	
THREE-SIDED ENCLOSURE (7-PARALLEL STEEL CONDUITS, FIVE 2", ONE 2+", AND ONE 3")	168	175	125	146	145	159						SAT	
TEST ASSEMBLY 2-6 REPORT NO. 11960-97259 TEST DATE: 10/19/94	CONDITIONS OF ACCEPTANCE (ßF) INITIAL TEMPERATURE = 78 ßF MAX. AVG. TEMPERATURE = 328 ßF MAX. SINGLE POINT TEMPERATURE = 403 ßF FIRE RATING PERIOD: 1-HOUR										BARRIER CONDITION		
SPECIMENS	FRONT LEFT CONDUIT		FRONT RIGHT CONDUIT		REAR LEFT CONDUIT		REAR RIGHT CONDUIT		PULL BOX INTERNAL SURFACE		UNSAT	SAT	
FOUR-SIDED CONDUIT ENCLOSURE (EIGHT 4" DIAMETER ALUMINUM CONDUITS)	AVG 227	MAX 243	AVG 217	MAX 224	AVG 215	MAX 228	AVG 213	MAX 219	AVG	MAX		SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA.
FOUR-SIDED CONDUIT ENCLOSURE (FOUR 1" DIAMETER STEEL CONDUITS)	233	252	232	252	224	234	223	232				SAT	
FOUR-SIDED CONDUIT ENCLOSURE (FOUR 3" DIAMETER STEEL CONDUITS)	230	242	228	235	221	225	210	219				SAT	
60"x 12"x 12" CABLE PULL BOX									225	240		SAT	

TABLE 2 - CONTINUED
PHASE 2 - CABLE TRAY AND UNIQUE CONFIGURATION TEST PROGRAM
THERMO-LAG 330-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 2-7 REPORT NO.: 11960-97260 TEST DATE: 10/18/94	THERMAL PERFORMANCE										BARRIER CONDITION		REMARKS
	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 80 EF MAX. AVG. TEMPERATURE = 330 EF MAX. SINGLE POINT TEMPERATURE = 405 EF FIRE RATING PERIOD: 1-HOUR										UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	REAR CONDUIT SURFACE		MIDDLE CONDUIT SURFACE		FRONT CONDUIT SURFACE		INDIVIDUAL CONDUIT SURFACE		INTERNAL CONDUIT				
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
SEVEN 4" DIAMETER STEEL CONDUITS IN A COMMON ENCLOSURE.	228	287	212	237	230	286						SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA.
3/4" DIAMETER STEEL CONDUIT							220	233	213	227		SAT	
3/4" DIAMETER ALUMINUM CONDUIT							216	226	210	216		SAT	

Note 1 - Temperatures measured by the bare 8 AWG copper conductor installed on top of the cables.

Note 2 - Temperatures measured by the bare 8 AWG copper conductor installed beneath the cable tray rungs.

Note 3 - *Temperatures measured by the bare 8 AWG copper conductor installed on top of cable tray rungs.*

TABLE 3

PHASE 3 - CABLE TRAY, CONDUIT, AND JUNCTION BOX CONFIGURATION TEST PROGRAM
THERMO-LAG 330-1/770-1 FIRE BARRIER SYSTEMS

TEST ASSEMBLY 3-1	THERMAL PERFORMANCE										BARRIER CONDITION		REMARKS
REPORT NO.: 11960-97555 TEST DATE: 12/15/94	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 68 EF MAX. AVG. TEMP. = 318 EF MAX. SINGLE POINT TEMP. = 393 EF FIRE RATING PERIOD: 3-HOURS										UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH =HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	LEFT RAIL		RIGHT RAIL		TOP OF RAIL		JUNCTION BOX SURFACE						
12" WIDE STEEL CABLE TRAY	AVG 228	MAX 238	AVG 230	MAX 244	AVG 222	MAX 229	AVG	MAX				SAT	FIRE RATING 3 1/2 HOURS
24" WIDE STEEL CABLE TRAY	220	235	225	242	211	217						SAT	
JUNCTION BOX (12" x 12" x 60")							219	226				SAT	
TEST ASSEMBLY 3-2 REPORT NO. 11960-97553 TEST DATE: 01/10/95	CONDITIONS OF ACCEPTANCE (EF) INITIAL TEMPERATURE = 64 EF MAX. AVG. TEMPERATURE = 314 EF MAX. SINGLE POINT TEMPERATURE = 389 EF FIRE RATING PERIOD: 3-HOURS										BARRIER CONDITION		
SPECIMENS	LEFT RAIL		RIGHT RAIL		TOP OF RUNGS		CONDUIT SURFACE		INSIDE CONDUIT OR AIR DROP		UNSAT	SAT	
12" WIDE STEEL CABLE TRAY	AVG 251	MAX 272	AVG 251	MAX 271	AVG 247	MAX 261	AVG	MAX	AVG	MAX		SAT	FIRE RATING 4 HOURS
24" WIDE STEEL CABLE TRAY	231	247	240	255	232	241						SAT	
5" DIA. STEEL CONDUIT							263	327	256	295		SAT	
2" DIA. STEEL CONDUIT							310	378	311	368		SAT	
1" DIA. STEEL CONDUIT							288	342	279	318		SAT	
2" DIA. AIR DROP									207	208		SAT	

TABLE 4

WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
CONDUITS (S=STEEL; A=ALUMINUM):						
3/4-INCH (S & A) 1-INCH (S)	(5/8")	(3/8" - OVERLAY)	(PBTG-BASE/OVERLAY)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3 AND 1-5
1-1/2-INCH (S) 2-INCH (S) 3-INCH (S)	(3/8")	(3/8" - OVERLAY)	(PBTG-BASE/OVERLAY)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3, 1-4 AND 1-5
4-INCH (S) 5-INCH (S)	(5/8")		(PBTG-BASE)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3, 1-5 AND 1-6
CABLE TRAYS (STEEL):						
18-INCH 18-INCH / RAISED STEEL COVER	(5/8")	(S-SKIN/TG OVERLAY)	(SINGLE PIECE-TOP), (SCORE & FOLD-BOTTOM/SIDES), (PBTG-BASE/OVERLAY)	(T-WIRE)	CABLE FILL MUST BE GREATER THAT 1.33 LBS/FT	TEST ASSEMBLY 2-1 AND 2-3

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.	(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).	(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAS BEEN USED TO CONSTRUCT THE ENCLOSURE.	(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).	(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.
(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.	(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT Preshape HAS A NOMINAL 3/8-INCH THICKNESS.	(STITCH) = THE USE OF STAINLESS STEEL TIE-WIRES TO LACE A JOINT OR SEAM TOGETHER.	(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).	(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT Preshape IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
COMMON CABLE TRAY ENCLOSURE:						
FOUR-SIDED 3-TRAY ENCLOSURE	(5/8")	(S-SKIN/TG OVERLAY)	(M-PIECE), (PBTG-BASE/OVERLAY)	(T-WIRE)	THREE 18-INCH TRAYS, HORIZONTAL STACK CONFIGURATION STEEL ANGLES/THREADED RODS TO HOLD FIRE BARRIER AGAINST VERTICAL TRAY STACK SURFACE FIRE BARRIER BOLTED TO STEEL ANGLES	TEST ASSEMBLY 2-3
SPECIAL CABLE TRAY FITTING (STEEL):						
DOUBLE CROSS (18-INCH TRAYS)	(5/8")	(S-SKIN/TG OVERLAY)	(M-PIECE), (PBTG-BASE/OVERLAY)		STEEL ANGLES USED TO SUPPORT HORIZONTAL FIRE BARRIER PANELS, SEAMS BETWEEN PANELS LOCATED OVER STEEL ANGLES 3/8" FLAT FIRE BARRIER PANEL INSTALLED OVER SEAMS FIRE BARRIER MATERIAL BOLTED TO STEEL ANGLES	TEST ASSEMBLY 2-2

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.	(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).	(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAS BEEN USED TO CONSTRUCT THE ENCLOSURE.	(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).	(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.
(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.	(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT Preshape HAS A NOMINAL 3/8-INCH THICKNESS.	(STITCH) = THE USE OF STAINLESS STEEL TIE-WIRES TO LACE A JOINT OR SEAM TOGETHER.	(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).	(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT Preshape IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
LATERAL BEND CONDULETS (STEEL):						
1-INCH	(5/8")	(3/8" - OVERLAY)	(PBTG-BASE/OVERLAY), (SCORE & FOLD), (STITCH)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3
1-1/2-INCH 2-INCH 3-INCH	(3/8")	(3/8" - OVERLAY)	(PBTG-BASE/OVERLAY), (SCORE & FOLD), (STITCH)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3 AND 1-4
4-INCH	(5/8")		(PBTG-BASE/OVERLAY), (SCORE & FOLD), (STITCH)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3 AND 1-6
LATERAL SIDE CONDULETS (STEEL):						
2-INCH	(5/8")	(S-SKIN/TG-OVERLAY)	(PBTG-BASE), (SCORE & FOLD)	ANCHORED W/BOLTS AND SLEEVES TO CONCRETE SLAB WITH 5/8" T-LAG BASE PLATES	CONDULET MOUNTED NEAR CONCRETE SLAB	TEST ASSEMBLY 1-5
90E CONDUIT RADIAL BENDS (S=STEEL; A=ALUMINUM):						
3/4-INCH (S & A) 1-INCH (S)	(5/8")	(3/8" - OVERLAY), (S-SKIN/TG-OVERLAY)	(PBTG-BASE/OVERLAY), (SCORE & FOLD)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3 AND 2-7

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.

(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).

(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAVE BEEN USED TO CONSTRUCT THE ENCLOSURE.

(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).

(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.

(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.

(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.

(STITCH) = STAINLESS STEEL TIE-WIRES USED TO LACE A JOINT OR SEAM TOGETHER.

(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).

(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT PRESHAPE IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
90B RADIAL BENDS - CONT.						
1-1/2-INCH 2-INCH 3-INCH	(3/8")	(3/8" - OVERLAY), (S-SKIN/TG-OVERLAY)	(PBTG-BASE/OVERLAY), (SCORE & FOLD)	(T-WIRE)	NONE	TEST ASSEMBLY 1-3 AND 1-4
4-INCH	(5/8")		(PBTG-BASE), (SCORE & FOLD)			TEST ASSEMBLY 1-3
JUNCTION (STEEL) BOXES (JB):						
6"x 6"x 6" 12"x 12"x 8"	(5/8")	(S-SKIN/TG-OVERLAY)	(PBTG-BASE), (SCORE & FOLD)	ANCHORED W/BOLTS AND SLEEVES TO CONCRETE SLAB WITH 5/8" T-LAG BASE PLATES	JB MUST BE INSTALLED AGAINST A CONCRETE SLAB	TEST ASSEMBLY 1-5
18"x 12"x 8"	(5/8")	(S-SKIN/TG-OVERLAY ON JOINTS ONLY)	(PBTG-BASE), (SCORE & FOLD)	SAME METHOD OF ATTACHMENT AS 6"x6"x6" JB	JB MUST BE INSTALLED AGAINST A CONCRETE SLAB	TEST ASSEMBLY 1-5
20"x 12"x 12"	(5/8")		(PBTG-BASE), (JB SIDES - SCORE & FOLD), (COVER - SINGLE PIECE)	SAME METHOD OF ATTACHMENT AS 6"x6"x6" JB T-LAG REMOVABLE JB COVER HELD IN PLACE WITH 1/4" NUTS AND STUDS	JB MUST BE INSTALLED AGAINST CONCRETE SLAB REMOVABLE COVER STRESS SKIN OVERLAP STAPLED TO FIRE BARRIER SIDE PANELS	TEST ASSEMBLY 1-5

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.

(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).

(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAVE BEEN USED TO CONSTRUCT THE ENCLOSURE.

(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).

(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.

(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.

(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT Preshape HAS A NOMINAL 3/8-INCH THICKNESS.

(STITCH) = USED STAINLESS STEEL TIE-WIRES LACE A JOINT OR SEAM TOGETHER.

(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).

(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT Preshape IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
JUNCTION BOXES (STEEL):						
24"x 18"x 12"	(5/8")		(PBTG-BASE), (JB SIDES FORMED FROM TWO T-LAG PANEL PIECES - SCORE & FOLD), (COVER - SINGLE PIECE)	ANCHORED W/BOLTS AND SLEEVES TO CONCRETE SLAB WITH 5/8" T-LAG BASE PLATES T-LAG REMOVABLE JB COVER HELD IN PLACE WITH 1/4" NUTS AND STUDS	JB MUST BE INSTALLED AGAINST CONCRETE SLAB REMOVABLE COVER STRESS SKIN OVERLAP STAPLED TO FIRE BARRIER SIDE PANELS	TEST ASSEMBLY 1-5
48"x 36"x 12"	(5/8")	(3/8" - OVERLAY), (S-SKIN/TG-OVERLAY ON JOINTS ONLY)	(PBTG-BASE/OVERLAY), (M-PIECE)	ANCHORED W/BOLTS AND SLEEVES TO CONCRETE SLAB WITH 5/8" T-LAG BASE PLATES T-LAG REMOVABLE JB COVER HELD IN PLACE WITH 1/4" NUTS AND STUDS	JB MUST BE INSTALLED AGAINST CONCRETE SLAB REMOVABLE COVER STRESS SKIN OVERLAP STAPLED TO FIRE BARRIER SIDE PANELS	TEST ASSEMBLY 1-6
60"x 36"x 24"	(5/8")	(S-SKIN/TG OVERLAY)	(PBTG-BASE/OVERLAY)	FIRE BARRIER MATERIAL BOLTED TO JB	JB ATTACHED DIRECTLY TO CONCRETE WALL	TEST ASSEMBLY 2-5
PULL BOX:						
60"x 12"x 12"	(5/8")	(S-SKIN/TG OVERLAY)	(PBTG-BASE/OVERLAY)	(T-WIRE)		TEST ASSEMBLY 2-6

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.

(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).

(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAVE BEEN USED TO CONSTRUCT THE ENCLOSURE.

(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).

(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.

(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.

(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.

(STITCH) = STAINLESS STEEL TIE-WIRES USED TO LACE A JOINT OR SEAM TOGETHER.

(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).

(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT PRESHAPE IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
FOUR-SIDED ENCLOSURES:						
33"x 16" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(PRE-S/M-PIECE), (PBTG-BASE/OVERLAY)	(T-WIRE)	APPLICATION ON CONDUITS ONLY (2-PARALLEL CONDUIT BANKS, 4-4" DIAMETER CONDUITS IN EACH BANK) SEAMS BETWEEN 36" WIDE PANELS BACKED WITH 5/8" PANEL MATERIAL AND BOLTED TOGETHER	TEST ASSEMBLY 2-6
8"x 8" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/OVERLAY)	(M-PIECE), (PBTG-BASE/OVERLAY)	(T-WIRE)	APPLICATION ON CONDUITS ONLY (2-PARALLEL CONDUIT BANKS, 2-1" DIAMETER CONDUITS IN EACH BANK)	TEST ASSEMBLY 2-6
18"x 18" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(SCORE & FOLD), (PBTG-BASE/OVERLAY)	(T-WIRE)	APPLICATION ON CONDUITS ONLY (2-PARALLEL CONDUIT BANKS, 2-3" DIAMETER CONDUITS IN EACH BANK)	TEST ASSEMBLY 2-6
36"x 6" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(PRE-S/M-PIECE), (PBTG-BASE/OVERLAY)	(T-WIRE)	SEVEN PARALLEL 4" DIAMETER CONDUITS THREADED RODS USED TO BOLT TOP AND BOTTOM FIRE BARRIER PANELS TO RACEWAY	TEST ASSEMBLY 2-7

LEGEND:

(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.	(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).	(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAS BEEN USED TO CONSTRUCT THE ENCLOSURE.	(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).	(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.	(PRE-S/M-PIECE)= CONDUIT FIRE BARRIER PreshapeS USED TO FORM CORNER JOINTS OR END SIDES. FLAT PANELS USED TO FORM SIDES BETWEEN PreshapeS.
(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.	(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT Preshape HAS A NOMINAL 3/8-INCH THICKNESS.	(STITCH) = THE USE OF STAINLESS STEEL TIE-WIRES TO LACE A JOINT OR SEAM TOGETHER.	(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).	(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT Preshape IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).	

TABLE 4 - CONTINUED
WATTS BAR NUCLEAR PLANT
*SUMMARY OF ACCEPTABLE 1-HOUR THERMO-LAG 330-1 ERFBS
AND APPLICATION TECHNIQUES*

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
TWO-SIDED ENCLOSURES:						
33" x 33" 18" x 12" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(M-PIECE), (PBTG-BASE/OVERLAY)	FIRE BARRIER BOLTED TO UNISTRUT FRAME	UNISTRUT FRAME NOT IN CONTACT WITH PROTECTED RACEWAY TWO SIDES OF ENCLOSURE FORMED BY CONCRETE WALLS FIRE BARRIER PANEL SEAMS NOT OVER FRAME REQUIRE BACKING BOARD	TEST ASSEMBLY 2-4
THREE SIDED ENCLOSURES:						
18"x 6" 6"x 6" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(SCORE & FOLD), (PBTG-BASE/OVERLAY)	(T-WIRE)	TOP OR ONE SIDE OF ENCLOSURE MUST BE CONCRETE SLAB	TEST ASSEMBLY 2-5
28"x 6" (APPROXIMATE DIMENSIONS)	(5/8")	(S-SKIN/TG OVERLAY)	(M-PIECE), (PBTG- BASE/OVERLAY)	(T-WIRE)	TOP OR ONE SIDE OF ENCLOSURE MUST BE CONCRETE SLAB	TEST ASSEMBLY 2-5
LEGEND:						
(5/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 5/8-INCH THICKNESS.	(PBTG-BASE/OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 330-1 (Note 1).	(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG PANEL HAS BEEN USED TO CONSTRUCT THE ENCLOSURE.	(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE ERFBS TOGETHER (Note 2).	(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.		
(3/8") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 3/8-INCH THICKNESS.	(3/8" - OVERLAY) = THERMO-LAG FIRE BARRIER PANEL OR CONDUIT Preshape HAS A NOMINAL 3/8-INCH THICKNESS.	(STITCH) = THE USE OF STAINLESS STEEL TIE-WIRES TO LACE A JOINT OR SEAM TOGETHER.	(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS TOGETHER (Note 2).	(SCORE & FOLD) = SINGLE PIECE OF THERMO-LAG PANEL OR CONDUIT Preshape IS USED TO FOR THE RACEWAY ENCLOSURE (Note 3).		

Note 1 - Before installation, the inner surfaces, joints, and seams of the Thermo-Lag fire barrier material were prebuttered with trowel-grade material.

Note 2 - Stainless steel bands and tie-wire are spaced every 6 inches (maximum) on straight runs of conduits and every 4 inches (maximum) on conduit radial bends.

Note 3 - The Thermo-Lag fire barrier panel or conduit preshape is scored or cut down to the inner stress skin. Along the line of the cut, the fire barrier panel or conduit preshape can be folded to form a joint. This method can be used to form junction box, lateral bend or side condulet, and conduit radial bend enclosures

TABLE 5

WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 3-HOUR THERMO-LAG 330-1/770-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
CONDUITS (STEEL):						
1-INCH	(1-1/4")	(MAT OVERLAY, 3-LAYERS)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE),(BANDS)	NONE	TEST ASSEMBLY 3-2
2-INCH	(1-1/4")	(MAT OVERLAY, 2-LAYERS)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE),(BANDS)	NONE	TEST ASSEMBLY 3-2
4-INCH	(1-1/4")	(MAT OVERLAY, 2-LAYERS)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE),(BANDS)	NONE	TEST ASSEMBLY 3-2
LATERAL BEND CONDULETS (STEEL):						
1-INCH	(1-1/4")	(MAT OVERLAY, 3-LAYERS), (S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE),(BANDS)	NONE	TEST ASSEMBLY 3-2
2-INCH	(1-1/4")	(MAT OVERLAY, 2-LAYERS), (S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE),(BANDS)	NONE	TEST ASSEMBLY 3-2
3-INCH	(1-1/4")	(MAT OVERLAY, 2-LAYERS), (S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE), (BANDS)	NONE	TEST ASSEMBLY 3-2

LEGEND:

(1-1/4") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 1 1/4-INCH THICKNESS.

(PBTG-OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 770-1.

(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG 330-1 PANEL HAS BEEN USED TO CONSTRUCT BASELINE ERFBS ENCLOSURE.

(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE BASELINE ERFBS TOGETHER.

(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.

(MAT OVERLAY) = FIRE BARRIER MAT MATERIAL HAS A NOMINAL 3/8-INCH THICKNESS.

(POST-TG BASELINE) = BASELINE FIRE BARRIER PANEL OR CONDUIT Preshape POST BUTTERED WITH THERMO-LAG 770-1 TROWEL GRADE MATERIAL.

(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS/OVERLAY TOGETHER.

TABLE 5 - CONTINUED
WATTS BAR NUCLEAR PLANT
SUMMARY OF ACCEPTABLE 3-HOUR THERMO-LAG 330-1/770-1 ERFBS
AND APPLICATION TECHNIQUES

PROTECTED RACEWAY COMPONENT	THICKNESS - BASELINE MATERIAL	UPGRADE	ERFBS APPLICATION TECHNIQUES	ATTACHMENT	LIMITATIONS AND RESTRICTIONS	QUALIFICATION BASES
CABLE TRAYS (STEEL):						
12" WIDE CABLE TRAY	(1-1/4")	(MAT OVERLAY, 2-LAYERS), (AT 90 E BEND S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE), (BANDS)	NONE	TEST ASSEMBLY 3-1 AND 3-2
24" WIDE CABLE TRAY	(1-1/4")	(MAT OVERLAY, 2-LAYERS), (AT 90 E BEND S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE), (BANDS)	NONE	TEST ASSEMBLY 3-1 AND 3-2
JUNCTION BOX (STEEL):						
12"x 12"x 60"	(1-1/4")	(MAT OVERLAY, 2-LAYERS), (S-SKIN/TG OVERLAY ON BASELINE)	(M-PIECE), (POST-TG BASELINE), (PBTG-OVERLAY)	(T-WIRE), (BANDS)	NONE	TEST ASSEMBLY 3-1

LEGEND:

(1-1/4") = BASE THERMO-LAG FIRE BARRIER PANEL OR CONDUIT PRESHAPE HAS A NOMINAL 1 1/4-INCH THICKNESS.

(PBTG-OVERLAY) = PREBUTTERED WITH TROWEL-GRADE THERMO-LAG 770-1.

(M-PIECE) = MULTIPLE PIECES OF THERMO-LAG 330-1 PANEL HAS BEEN USED TO CONSTRUCT BASELINE ERFBS ENCLOSURE.

(BANDS) = STAINLESS STEEL BANDS USED TO HOLD THE BASELINE ERFBS TOGETHER.

(S-SKIN/TG OVERLAY) = STAINLESS STEEL STRESS SKIN OVERLAY COVERED WITH 1/8-inch-thick TROWEL-GRADE COATING. STAPLES USED TO SECURE STRESS SKIN TO BASE MATERIAL.

(MAT OVERLAY) = FIRE BARRIER MAT MATERIAL HAS A NOMINAL 3/8-INCH THICKNESS.

(POST-TG BASELINE) = BASELINE FIRE BARRIER PANEL OR CONDUIT PRESHAPE PREBUTTERED WITH THERMO-LAG 770-1 TROWEL GRADE MATERIAL.

(T-WIRE) = STAINLESS STEEL TIE-WIRE USED TO HOLD THE ERFBS/OVERLAY TOGETHER.

ENCLOSURE 4

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

SUPPLEMENTAL SAFETY EVALUATION REPORT 19 ANNOTATED

(Note that the layout of the text on the following pages of this enclosure depicts the text as it is in the SSER)

APPENDIX FF*
SAFETY EVALUATION
WATTS BAR NUCLEAR PLANT FIRE PROTECTION PROGRAM
DOCKET NOS. 50-390/391
(TAC M63648)

~~3.0 GENERAL PLANT FIRE PROTECTION AND SAFE SHUTDOWN FEATURES~~

~~3.1 Fire Protection Design~~

~~3.1.1 Building and Compartment, Fire Barriers~~

~~In SSER 18, the staff indicated that all floors, walls, and ceilings enclosing the control room and the cable spreading room are fire rated at a minimum of 3 hours. However, the actual "as-built" condition is that he walls enclosing the control room and the cable spreading room are rated at a minimum of 3 hours. In addition, the main control room area contains peripheral rooms which that are located within the main control room complex. These peripheral rooms are separated from the main control room by 1-hour fire-rated barriers in lieu of 1-1/2-hour barriers as stated in SSER 18.~~

~~In SSER 18, the staff indicated that fire barriers in buildings or compartments (walls, ceilings, floors) are constructed either of reinforced concrete or of reinforced-concrete blocks. Further, the concrete fire barriers are a minimum 12 inches thick and the concrete block barriers are normally 8 inches thick. However, the reinforced-concrete fire barriers are actually 8 inches thick (minimum thickness).~~

~~The staff concludes that these "as-built" conditions do not affect the conclusions made in SSER 18 and, therefore, are acceptable.~~

3.1.4 Fire Barrier Penetration Seals

3.1.4.1 Electrical and Mechanical Penetration Seals

In Watts Bar Fire Protection Report (FPR) Sections II.12.6, VIII.D.1.j, and D.3.d, the applicant committed to install fire barrier mechanical and electrical penetration seals that were qualified by tests meeting the guidance and acceptance criteria of the American Society for Testing and Material (ASTM) Standard E814-1994, "Standard Test Method for Fire Tests of Through-Penetration Fire Stops" (for mechanical fire barrier penetration seals) and Institute of Electrical and Electronics Engineers (IEEE) Standard 634-1978, "IEEE Standard Cable Penetration Fire Stop Qualification Test" (for electrical fire barrier penetration seals).

At the time of the July 1995 audit, the applicant had not completed its engineering analysis and evaluation of fire barrier penetration seals. Based

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*This appendix was originally published in SSER 18; the evaluation here supplements or revises that evaluation.

on a preliminary review of portions of this draft penetration seal program assessment engineering report (Report No. 0006-00922-02A, Revision 0A), the staff specifically identified concerns regarding qualification testing and extrapolation of thermal performance data for cable slots, large cable tray blockouts and large diameter mechanical sleeves. In addition, the staff determined that: (1) the tests did not meet the applicant's commitments described in the FPR; (2) the test specimens in the qualification test reports are either not representative of or bound the as-built penetration seal conditions; (3) the acceptability of the bounding conditions for the critical fire penetration seal material and design attributes (e.g., material density, location/need for damming boards, amount and type of cables penetrating the seal test specimens) were not clear; (4) the installation details and their qualification basis did not clearly establish the fire endurance rating of the seal design; (5) testing of similar test specimens did not yield consistent thermal performance results; (6) the qualification testing referenced by the draft engineering report generally deviated significantly from the testing (collection of thermal performance data) guidance provided in industry fire endurance penetration seal testing standards; and (7) the applicant had not properly evaluated the auto-ignition temperatures (refer to IEEE 634 for guidance) of the various types of cable jacket and insulation used and pass-through fire-rated penetration seals.

By letter dated October 5, 1995, the applicant submitted its fire barrier penetration seal engineering evaluations. This report (1) documents the typical fire barrier seal configurations used at the Watts Bar Nuclear Plant; (2) defines the basis of the acceptability of fire-rated penetration seal typical details; (3) establishes the bounding parameters for each fire barrier penetrations seal design; (4) provides a detailed description of the extent to which Watts Bar meets appropriate penetration seal testing standards; and (5) documents the acceptability of the typical penetration seal designs. In addition, this submittal documents the applicant's commitment to perform additional penetration seal fire testing.

In lieu of developing the design for 63 different fire barrier penetration seal details used at WBN from known tested configurations (e.g., penetration seal detail designed to be representative of a tested configuration), the applicant elected to develop the required penetration details from as-built plant conditions; therefore, the applicant has as-built penetration seals which are not representative of the tested configurations. Thus, in its engineering evaluation, the applicant has backfitted the test results of qualified configurations (which in many cases are not representative of the Watts Bar penetration seal design detail), and has extrapolated data and performance observations which it concludes justifies its typical design details.

In addition, the applicant, in its engineering evaluation, reviewed the qualification tests which it relied on to qualify its typical seal designs and compared them to the testing protocol established by either ASTM E-814-1983 (for mechanical seals) or IEEE 634-1978 (for electrical seals). Where testing protocol deviations were noted, the applicant provided technical justification for these deviations.

The applicant, in its comparison of the Watts Bar typical penetration seal design details to the tested attributes of those seals in the qualification tests, made the following assumptions:

- Penetration seal assemblies successfully tested for a specific barrier thickness and type bound similar configurations installed in a thicker barrier of a same type.

  (Note - The staff agrees with the applicant's assumption, providing that the similar configurations suggested by this assumption are truly representative of the tested configuration.)

- Penetration seal assemblies successfully tested in lined openings bound similar configurations installed in unlined openings.

  (Note - The staff agrees with this assumption.)

- Penetration seal assemblies successfully tested for a specific opening size bound similar configurations of a smaller opening size.

  (Note - The staff agrees with this assumption, providing that the penetration seal is blank and has no penetrants. Size of penetrants, their thermal mass and conductivity, arrangement or configuration within the seal are important factors with regard to seal performance. In addition, seal thickness is affected by the thermal mass and conductivity of the penetrants and the fire barrier system being penetrated.)

- Penetration seal assemblies successfully tested for a specific maximum free area bound similar configurations with a smaller free area.

  (Note - The staff agrees with this assumption, providing that the test specimen is representative of the as-built plant configuration (e.g., the free area of cable tray blockout with two 18-inch-wide trays penetrating it would bound a cable tray blockout (similar blockout dimensions) with two 24-inch trays penetrating it, providing the thermal mass and conductivity of the penetrating items is less).

- Penetration seal assemblies successfully tested for a specific cable fill bound similar configurations with a small cable fill. This condition may also be applied to an internal seal within the plane of the barrier.

  (Note - The staff agrees with this assumption, providing the cable material composition is the same and the thermal mass of copper is less than what was tested in the test specimen.)

- Penetration seal assemblies successfully tested for a specific cable type bound similar configurations with cable types in which the auto-ignition temperatures of the cable jacket is equal to or greater than the jacket on the cables used in the test. Cable types tested in configurations used to bound Watts Bar typical details were either PVC, neoprene, or hypolon (chlorosulfonated polyethylene) jacketed. These cable jacketed materials are similar to the cable jacket materials used at Watts Bar with respect to auto-ignition temperature, and, therefore, bound Watts Bar configurations.

(Note - The staff agrees with this assumption, providing that the test specimen cable jacket auto-ignition temperatures and the cable jackets used in the plant have been determined by subjecting them to the same standard test method (ANSI K65.111-1971) for determining ignition temperature.)

The staff has performed a review of this submittal. Specifically, this was an audit type review of mechanical and electrical penetration seal designs. This review was limited to the information presented in the applicant's penetration seal program engineering report (Report No. 0006-00922-02, Revision: 0) and for the specific penetration seals audited, the staff did not evaluate the applicability of the test specimens and their representation of as-built plant conditions, thermal data and fire performance of these specimens as reflected in these referenced test reports.

The staff in its review of the Watts Bar fire barrier penetration seal program used the guidance of Appendix A to APCSB 9.5-1, the applicant's commitment to ASTM E-814-1983 and IEEE 634-1978, the guidance of Information Notice (IN) 88-04, and Generic Letter (GL) 86-10. The staff in IN 88-04 provided a summary of existing staff guidance related to fire barrier penetration seals. Specifically, Appendix A to IN 88-04, Item A stated the general considerations concerning the use of test results to qualify fire barrier penetration seal designs which are: "The (fire barrier seal) test specimen shall be truly representative of the construction for which classification is desired, as to materials, workmanship, and details such as dimensions of parts, and shall be built under the conditions representative of those obtaining as practically applied in building construction and operation."

IEEE 634 states that the qualification fire endurance test program for electrical penetration seals should include tests of penetration seal designs representative of the in-plant configuration. This standard: (1) gives guidance on bounding cable fill conditions; (2) gives guidance on the size of the penetration openings; (3) requires that the test specimen have a cable fill representative of its end use and the plant-specific cable construction (e.g., if end use was a tray filled with cross-linked polyethylene instrument cables, the test specimen should be representative of this condition); (4) gives guidance on the temperature conditions on the unexposed surface of the test specimen; (5) recommends that at least three thermocouples be located on the surface of the penetration seal to measure the temperature on the material's face; and (6) states that temperatures shall be measured at the cable jacket, cable penetration fire stop interface, and the interface between the fire stop and through-metallic components.

ASTM Standard E-814 states that the test specimens for the mechanical penetration seals shall be representative of actual field installations. The standard: (1) gives guidance on determining the temperature conditions on the unexposed surface of the test specimen; (2) recommends that at least three thermocouples be located on the surface (under insulated thermocouple pads) of the penetration seal to measure the temperature on the material's face; and (3) states that temperatures shall be measured at the interface between the fire stop and through-penetrating metallic component.

In GL 86-10, the guidance related to fire barrier penetration seals is provided in Appendix R Interpretation 4, Fire Area Boundaries. This interpretation states "In order to meet the regulation, fire area boundaries need not be completely sealed floor-to-ceiling, wall-to-wall boundaries. However, all unsealed openings should be identified and considered when evaluating the effectiveness of the overall barrier. Where fire area boundaries are not wall-to-wall, floor-to-ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, licensees must perform an evaluation to assess the adequacy of fire boundaries in their plants to determine if the boundaries will withstand the hazards associated with the area."

The staff as part of its penetration seal review audited the various typical Watts Bar seal design details. This audit consisted of reviewing the design detail against the tested configuration and its test results. From the applicant's cited test results, the staff made a determination if they were representative of and bound the as-built plant conditions. The following summarizes the design details reviewed:

Mechanical Penetration Seal Design Details

a. Details I, I (F-rated), V, V (F-rated), VIII, VIII (F-rated), XXII, XXII (F-rated), XL, XL (F-rated), XLIII, XLIII (F-rated), XLV, XLV (F-rated), LVI, LVI (F-rated), LXXIX, LXXIX (F-rated), LXXX, LXXX (F-rated), LXXXIII, LXXXIII (F-rated), LXXXIV, LXXXIV (F-rated), LXXXV, LXXXV (F-rated), LXXXVI, and LXXXVI (F-rated) - (3-hour fire-rated designs with a single pipe or conduit penetrant, minimum silicone foam fill depth 12 inches)

   The staff's technical evaluation of these generic type penetration seal designs is presented below.

b. Details IX, IX (F-rated), X, X (F-rated), XI, and XI (F-rated) - (3-hour fire-rated designs with multiple pipe or conduit penetrant, minimum silicone foam fill depth 12 inches)

   The staff's technical evaluation of these generic type penetration seal designs is presented below.

c. Details III, XXXVI, C9, LC, and N3 - (3-hour fire-rated designs, minimum silicone foam seal fill depth 12 inches, maximum 14-inch-diameter penetration opening with no penetrating items)

d. Detail XXXIII - (3-hour fire-rated seal design with a single pipe or conduit penetrant, minimum moderate density silicone elastomer (MDSE) fill depth 12 inches)

The staff's technical evaluation of this generic type penetration seal design is presented below.

e. Moderate Density Silicone Elastomer Seals (Seal Depth 6 inches) - Details XLII, XLIV, XLVI, LX, and LXI - (3-hour fire-rated seal design with a single pipe or conduit penetrant, minimum MDSE fill depth 6 inches)

   The staff's technical evaluation of these generic type penetration seal designs is presented below.

f. Details XXXII, XXXVII, XLI, XLVII, LVII, and LXIII - (3-hour fire-rated seal design with a single pipe or conduit penetrant, minimum high density silicone elastomer (HDSE) fill depth 12 inches)

   The staff's technical evaluation of these generic type penetration seal designs is presented below.

g. Details L, LIX, and LXIV - (3-hour fire-rated design, boot type seal with a maximum 5-inch annular space between the penetrant and the penetration sleeve)

   The staff's technical evaluation of these generic type penetration seal designs is presented below.

Electrical Penetration Seal Design Details

a. Details, A2-2, B2-2, C-1, C2-2, K-1, L4-1, and L4-2 - (3-hour fire-rated 6-inch-diameter condulet and internal conduit type seal designs, silicone foam depth 6 inches)

b. Detail G2 - (2-hour fire-rated design with multiple cable tray penetrants, minimum silicone foam depth 10 inches)

c. Details L1, H1, A4, and M4 - (3-hour fire-rated cable slot penetration seal designs, 5-inch x 20-inch cable slots, minimum foam depth 12 inches, 1-inch-thick ceramic fiber damming boards installed over the opening on both sides of the penetration)

<u>Silicone Foam and Elastomer Density</u>

The applicant in its engineering report made the following assumptions regarding seal density ranges:

- The density range of 15-30 lb/ft3 allowed at Watts Bar for Dow Corning Silicone RTV Foam penetration seals is supported by successful fire tested configurations.

- The density range of 76-87.2 lb/ft3 allowed at Watts Bar for Dow Corning Sylgard 170 or GE RTV-6428 Elastomer penetration seals is supported by successful fire tested configurations.

- The density range of 150-173.5 lb/ft3 allowed at Watts Bar for high density silicone elastomer penetration seals is supported by successful fire tested configurations.

The staff reviewed the applicant's technical justification provided in its engineering report for the above silicone foam and elastomer density criteria. The staff audited the silicone foam penetration seal fire endurance tests referenced by the applicant's engineering report to determine if the above assumptions were adequately bounded by these tests. For example, Blockout 2 of test CTP-1001A is filled with 9-inch-thick foam seal with a density of 14.4 lb/ft3 and a 1-inch ceramic fiber board dam on the fire exposed side. This blockout was 26 inches x 42 inches and had two penetrating cable trays. At the end of its 3-hour fire exposure, the silicone foam surface temperature was 275 °F (171 °C). Test IC01091035, penetration PSS1 is filled with 8-3/4 inches of silicone foam with a density of 23.7 lb/ft3 and had a 1-inch ceramic fiber board on the fire exposed side. This penetration blockout was 24 inches x 24 inches and had two penetrating cable trays. At the end of the 3-hour fire exposure, the foam surface temperature was 249 °F (121 °C). From its review of the thermal data presented in the referenced tests, the staff finds that the density ranges set by the silicone foam and elastomer manufacturers, which are the same as those assumed by the applicant, have little impact on the thermal performance of a qualified penetration seal and, therefore, they are acceptable.

<u>Extrapolation of Low Density Foam Fire Endurance Test Data and Its Application to Moderate and High Density Silicone Elastomer Seal Designs</u>

The fire endurance performance of silicone elastomer is generally better than that of silicone foam. Tests have shown that a 20-inch-diameter pipe sleeve with a 16-inch penetrating pipe with the penetration annular space filled with 12 inches of silicone foam had a unexposed side foam surface temperature which was 254 °F (123 °C) greater than the same size test specimen sealed with 12 inches of moderate density silicone elastomer material. Generally, silicone elastomer seal material in a like penetration can be qualified by a silicone foam seal qualification test providing, the same seal depth is maintained and the seal's unsupported span and free area are qualified by similar tests using elastomer materials. For example, the Watts Bar cable slots are 5 inches x 20 inches and have been tested using silicone foam (12-inch fill depth) as the penetration sealant material. The staff would find, in this case, the use of silicone elastomer (12-inch fill depth) material in lieu of silicone foam an acceptable penetration sealant material.

<u>Extrapolation of Penetration Seal Fire Endurance Test Data</u>

The staff, in its review of mechanical penetration seal test data and the applicant's typical design details, has determined that the following factors can have a great effect on the thermal and structural performance of a penetration seal and the extrapolation of test data and its application to "as-built" plant conditions which are not representative of tested configurations:

- The quantity of through metallic components affects the amount of heat transferred to the unexposed side of the seal assembly and different types of penetrants transfer different amounts of heat. Additionally, larger penetrating items generally represent a more severe thermal condition for penetration sealant materials than do smaller items of the same type. Fewer of penetrating items are generally better than more.

- The smaller the annular space between the steel sleeve and the penetrating pipe, the more heat will be transferred into the silicone sealant material, thus accelerating its thermal degradation. In order to compensate for this, an increase in seal material depth or density is needed to qualify a seal design.

- The larger an unsupported span and free area a penetration seal material has across a blockout or a pipe penetration sleeve, the more likely it will fail structurally during a fire. From test experience, it appears that large span silicone foam seals perform better structurally than moderate and high density silicone elastomer seals.

The staff considered these factors in its review of the Watts Bar typical penetration seal design details.

<u>Mechanical Penetration Seals Silicone Foam Type</u>

Silicone Foam Seals (single penetrants) design details I, I (F-rated), V, V (F-rated), VIII, VIII (F-rated), XXII, XXII (F-rated), XL, XL (F-rated), XLIII, XLIII (F-rated), XLV, XLV (F-rated), LVI, LVI (F-rated), LXXIX, LXXIX (F-rated), LXXX, LXXX (F-rated), LXXXIII, LXXXIII (F-rated), LXXXIV, LXXXIV (F-rated), LXXXV, LXXXV (F-rated), LXXXVI, and LXXXVI (F-rated) are similar seal design details.

Silicone Foam Seals design details IX, IX (F-rated), X, X (F-rated), XI, and XI (F-rated) are similar to those design details identified above, except that their design allows multiple items to penetrate the seal.

All of these seals are pipe sleeve-type penetration and use silicone foam material (density range of 15-30 lb/ft3) to seal annular space between the penetration sleeve and the pipe/conduit penetrant(s) and are required to have a minimum foam fill depth of 12 inches. All of these designs use the following qualification tests to establish their design basis:

a. Construction Technology Laboratories Fire Test ICC1091035, "Fire and Hose Stream Test for Penetration Seal Systems," dated October 1990.

   Fire Test ICC1091035, Penetration 3, qualified a 14-inch-diameter steel pipe sleeve penetration filled with 12 inches (depth of seal material) of silicone foam in a 12-inch-thick concrete slab with no penetrating items as an effective 3-hour fire-rated design.

b. CTP 1076, "Three Hour Fire Qualification Test, HDLE, HDSE/HDLE Comparison, Radflex/Foam Composite Seal, Adhesive Sealant Conduit Seal, Nine Inch Silicone Foam W/O Damming, Radflex/Radflex B Comparison for Electrical and Mechanical Penetration Seals," dated March 28, 1985.

Fire Test CTP 1076, Penetration 6.1.17 qualified a 12-inch-diameter steel pipe sleeve penetration filled with 12 inches (depth of seal material) of silicone foam in a 12-inch-thick concrete slab with a 2- inch-diameter penetrating pipe as an effective 3-hour fire-rated design.

c. Bisco Report No. 748-49, "Fire Test Configuration for a Three Hour Rated Seal Utilizing BISCO SF-20 Where a Steel Sleeve Condition With Pipe Penetrant Exists," dated July 9, 1981.

Fire Test 748-49, Penetration 2, qualified a 12-inch-diameter steel pipe sleeve penetration filled with 12 inches (depth of seal material) of silicone foam in a 12-inch-thick concrete slab with an 8-inch-diameter penetrating pipe as an effective 3-hour fire-rated design.

d. GSU PO No. 93-H-72449, "Three Hour Fire Resistance Evaluation of Twelve Different Fire Penetration Seal Designs Contained Within Two Different Test Slabs," dated November 22, 1993.

Fire Test 93-H-72449, Penetration 11, demonstrated that a 20-inch- diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 16-inch-diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of silicone foam can resist the passage of flame through the penetration for a specified 3-hour fire test duration (Note - This test specimen did not meet the temperature rise and hose stream acceptance criteria established by ASTM E-814 and, therefore, is not considered a 3-hour design which meets the T-rating).

The staff reviewed the applicant's qualification tests cited above and, using this data, it independently determined the bounding design parameters established by these tests. The staff believes these qualification tests adequately demonstrate that "as-built" penetration seals which meet the following conditions will provide a level of fire safety equivalent to those which were tested: 1) 14-inch-diameter (and smaller) pipe sleeve installed in 12-inch-thick (minimum) concrete slab filled with 12 inches (minimum depth of seal material) of silicone foam; and 2) a 14-inch-diameter (or smaller) pipe sleeve installed in a 12-inch-thick (minimum) concrete slab with either a single or multiple penetrants (pipes or conduits) having a circumference ratio factor* (CrF) ranging from 0.16 to 0.66 and filled with a minimum 12 inches

* Circumference Ratio Factor (CrF) is established by dividing the circumference of the penetrant (for multiple penetrants, it would be the sum of the circumferences)*by the circumference of the penetration sleeve. The CrF range is established for' mechanical silicone foam or elastomer seal design by the qualification test. For example, Penetration 6.1.17 (Fire Test CTP-1076) is a 12-inch pipe sleeve filled with 12 inches of silicone foam penetrated by a 2-inch-diameter pipe and has a CrF of 0.16. Penetration 2 (Fire Test 748-49) is a 12-inch pipe sleeve filled with 12 inches of silicone foam penetrated by an 6-inch diameter pipe and has a CrF of 0.66. The CrF range established by these two tested configurations is 0.16 to 0.66. This range can then be used to evaluate 'as-built' configurations where the foam/elastomer fill depths were relatively the same as those tested and the largest pipe sleeve diameter evaluated does not

of silicone foam; and 3) a 20-inch-diameter pipe sleeve installed in a 12- inch-thick concrete slab with a single pipe penetrant having a CrF of 0.79 and filled with a minimum of 12 inches of silicone foam will prevent the passage of flame through the penetration and, therefore are acceptable.

Mechanical Penetrations - Moderate Density Silicone Elastomer Type

Watts Bar Typical Detail XXXIII is a pipe sleeve type penetration and is fire-rated for 3-hours. It uses MDSE material (density range of 76-87.2 lb/ft3); the penetration annular space between the penetration sleeve and the pipe/conduit penetrant is filled with MDSE to a depth of 12 inches. Watts Bar Typical Detail XXXVIII is similar in design to this penetration except that it does not have a penetrating item. The following qualification tests were used to establish the design basis for these detail:

a. Construction Technology Laboratories Fire Test ICC0286018, "Fire and Hose Stream Tests for Penetration Seal Systems (NMP2-PSS9)," dated April 1986.

   Fire Test ICC0286018, Penetration 1, qualified a 6-inch-diameter steel pipe sleeve penetration filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab with no penetrating items as an effective 3-hour fire-rated design.

b. Construction Technology Laboratories Fire Test ICC118520, "Fire and Hose Stream Tests for Penetration Seal Systems (NMP2-PSS11)," dated January 1986.

   Fire Test ICC0286020 qualified a 30-inch x 30-inch blockout with three penetrating items filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab as an effective 3-hour fire-rated design. This blockout tested a maximum unsupported free area of 17-inch x 30-inch (510 in2).

c. GSU PO No. 93-H-72449, "Three Hour Fire Resistance Evaluation of Twelve Different Fire Penetration Seal Designs Contained Within Two Different Test Slabs," dated November 22, 1993.

   Fire Test 93-H-72449, Penetration 12, qualified a 20-inch-diameter steel pipe sleeve penetration in a 12-inch-thick concrete slab with a 16-inch- diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of MDSE as an effective 3-hour fire-rated design.

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exceed the largest pipe sleeve tested. Therefore, it is expected that a 2-inch diameter pipe penetrating a 6-inch7diameter pipe sleeve filled with 12 inches of silicone foam (CrF =0.33) would provide an equivalent level of fire resistance to that established by these tested configurations. However, a 10-inch pipe penetrating a 12-inch-diameter sleeve filled with 12 inches of silicone foam (CrF = 0.85) would not achieve the same level of fire resistive performance.

d. Promatec Fire Test PRO293036, "Three Hour Fire Qualification Test, Comparison Test of ICMS Product 90 with D.C. Sylgard 170 and G.E. 6428 Elastomers," dated February 1993.

Fire Test PRO293036, Blockouts 1173.4-1 and 5-1, qualified a 12-inch x 12-inch (144 in2) blockout filled with 6 inches of MDSE and no penetrating items as an effective 3-hour fire-rated design.

The staff reviewed the qualification tests cited above and using this data it independently determined the bounding design parameters established by these tests. The staff believes these qualification tests adequately demonstrate that "as-built" penetration seals which meet the following conditions will provide a level of fire safety equivalent to those which were tested: 1) 17- inch-diameter (and smaller) pipe sleeve installed in 12-inch-thick (minimum) concrete slabs filled with a minimum 12 inches (depth of seal material) MDSE; and 2) a 16-inch-diameter (or smaller) pipe sleeve installed in a 12-inch- thick (minimum) concrete slab with a single pipe penetrant having a circumference ratio factor (CrF) ranging from 0 - 0.79 and filled with a minimum 12 inches of MDSE.

Details XLII, XLIV, XLVI, LX, and LXI are similar in design. They are all pipe sleeve type penetrations and fire-rated for 3 hours. They use MDSE material (density range of 76-87.2 lb/ft3), the penetration annular space between the penetration sleeve and the pipe/conduit penetrant(s) is (are) filled with MDSE to a depth of 6 inches, and they use the following qualification tests to establish the design basis for these details:

a. Construction Technology Laboratories Fire Test ICC0286018, "Fire and Hose Stream Tests for Penetration Seal Systems (NMP2-PSS9)," dated April 1986.

Fire Test ICC0286018, Penetration 1, qualified a 6-inch-diameter steel pipe sleeve penetration filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab with no penetrating items as an effective 3-hour fire-rated design.

b. Construction Technology Laboratories Fire Test ICC118520, "Fire and Hose Stream Tests for Penetration Seal Systems (NMP2-PSS11)," dated January 1986.

Fire Test ICC0286018 qualified a 30-inch x 30-inch blockout with three penetrating items filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab as an effective 3-hour fire-rated design. This blockout tested a maximum unsupported free area of 17-inches x 30 inches (510 in2).

c. GSU PO No. 93-H-72449, "Three Hour Fire Resistance Evaluation of Twelve Different Fire Penetration Seal Designs Contained Within Two Different Test Slabs," dated November 22, 1993.

Fire Test 93-H-72449, Penetration 12, qualified a 20-inch-diameter steel pipe sleeve penetration in a 12-inch-thick concrete slab with a 16-inch- diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of MDSE as an effective 3-hour fire-rated design.

d. Promatec Fire Test PRO293036, "Three Hour Fire Qualification Test, Comparison Test of ICMS Product 90 with D.C. Sylgard 170 and G.E. 6428 Elastomers," dated February 1993.

   Fire Test PRO293036, Blockouts 1173.4-1 and 5-1, qualified a 12 inches x 12 inches (144 in2) blockout filled with 6 inches of MDSE and no penetrating items as an effective 3-hour fire-rated design.

e. CTP-1142, "Three Hour Fire Qualification Test, Six (6) Inch Depth LDSE w/ Aluminum and Steel Penetrants, XLPE/PVC Cable," dated November 23, 1987.

   CTP-1142, Penetration 11, qualified a 48-inch x 48-inch blockout in a 12-inch concrete slab with various cable, conduit, cable tray of aluminum and steel penetrating the blockout as a 3-hour fire-rated seal. The blockout was sealed with 6 inches of Promatec LDSE (Promatec LDSE density range is the same as DC-170). The maximum free area tested by this test was 27.5 inches x 22 inches (605 in2).

The above tests were reviewed by the staff and, using this data, it independently determined the bounding design parameters established by these tests. The staff believes these qualification tests adequately demonstrate that "as-built" penetration seals which meet the following conditions will provide an equivalent level of fire safety to those which were tested: 1) 22-inch-diameter (and smaller) pipe sleeve installed in 12-inch-thick (minimum) concrete slab filled with a minimum 6 inches (depth of seal material) MDSE; and 2) a 30-inch-diameter (or smaller) pipe sleeve installed in a 12-inch- thick (minimum) concrete slab with either single or multiple penetrants (pipes or conduits) having a circumference ratio factor (CrF) ranging from 0.16 to 0.53 and filled with a minimum 6 inches of MCSE.

Mechanical Penetrations - High Density Silicone Elastomer Type

Details XXXII, XXXVII, XLI, XLVII, LVII, and LXIII are high density silicone elastomer (HDSE) seals and are similar in design. They are pipe sleeve type penetrations and fire-rated for 3-hours. These design details use HDSE material (density range of 150-173.5 lb/ft3) and have the penetration annular space between the sleeve and the pipe/conduit penetrant(s) is (are) filled with 6-inch (minimum depth) HDSE. The following qualification tests were used to establish the design basis for this detail:

a. Construction Technology Laboratories Fire Test ICC0286016, "Fire and Hose Stream Tests For Penetration Seal Systems (NMP2-PSS7)," dated March 1986.

   Fire Test ICC0286016, Penetration 6, qualified a 12-inch-diameter sleeve penetration in a 12-inch-thick concrete slab with a 2-inch-diameter pipe penetrant as an effective 3-hour fire-rated seal. The annular space between the pipe sleeve and the pipe was filled with 12 inches of HDSE.

b. Construction Technology Laboratories Fire Test ICC0382004, "Fire and Hose Stream Tests For Penetration Seal Systems," dated April 1982.

   Fire Test ICC0382004, Penetration 8, qualified a 12-inch-diameter sleeve penetration in a 12-inch-thick concrete slab with a 2-inch-diameter pipe penetrant as an effective 3-hour fire-rated seal. The annular space between the pipe sleeve and the pipe was filled with 12 inches of HDSE.

   Blockout 4 qualified a 36-inch x 36-inch blockout in 12-inch-thick (minimum) concrete slab penetrated by two 6-inch x 24-inch cable trays and a 6-inch-diameter conduit as an effective 3-hour fire-rated seal. This penetration was filled with 12 inches (minimum depth) of HDSE and had a maximum free area of 18 inches x 15 inches (270 in2).

c. Promatec Fire Test PRO293036, "Three Hour Fire Qualification Test, Comparison Test of ICMS Product 90 with D.C. Sylgard 170 and G.E. 6428 Elastomers," dated February 1993.

   Fire Test PRO293036, Blockouts 1173.1-1 and 2-1, qualified a 12-inch x 12-inch (144 in2) blockout filled with 12 inches of HDSE and no penetrating items as an effective 3-hour fire-rated design.

d. GSU PO No. 93-H-72449, "Three Hour Fire Resistance Evaluation of Twelve Different Fire Penetration Seal Designs Contained Within Two Different Test Slabs," dated November 22, 1993.

   Fire Test 93-H-72449, Penetration 8 qualified a 26-inch-diameter steel pipe sleeve penetration in a 12-inch-thick concrete slab with an 18-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of HDSE as an effective 3-hour fire-rated design.

The staff reviewed these tests, and using this data, it independently determined the bounding design parameters established by these tests. The staff believes these qualification tests adequately demonstrate that "as-built" penetration seals which meet the following conditions will provide a level of fire safety equivalent to those which were tested: 1) 15-inch-diameter and smaller pipe sleeve installed in 12-inch-thick (minimum) concrete slab filled with a minimum 12 inches (depth of seal material) HDSE; and 2) a 26-inch-diameter (or smaller) pipe sleeve installed in a 12-inch-thick (minimum) concrete slab with either a single or multiple penetrants (pipes or conduits) having a circumference ratio factor (CrF) ranging from 0.16 to 0.69 and filled with a minimum 12 inches of HDSE.

<u>Electrical Penetrations - Cable Slots (3-Hour Fire-Rated)</u>

Watts Bar penetration seal details A4, H1, L1, and M4 are 3-hour fire-rated penetration seal designs for 5-inch x 20-inch cable slots. These designs are filled with 12 inches (minimum foam depth) of silicone foam and have permanent 1- inch-thick ceramic fiber damming boards installed over the penetration opening on both sides. These damming boards are cut and fitted to allow the penetrating cables to pass through them. The applicant cited a number of qualification test reports* and used those tested configurations to support the design of the Watts Bar penetration seals. These tested configurations were large blockouts with multiple continuous cable trays passing through the penetration and were not representative of the "as-built" plant conditions. At Watts Bar the cable trays do not pass through the penetration. The applicant in Appendix G of its Penetration Seal Engineering Report stated its position on the applicability of these cable tray blockout tests to the Watts Bar "as-built" conditions.

The staff, as part of its review of the engineering report and existing plant-specific conditions, had questions regarding the thermal performance of Watts Bar cable slots and plant specific cable used at Watts Bar. The staff based its concerns on the following principles: 1) The quantity of through metallic components (e.g., large fill of power cables) affect the amount of heat transferred to the unexposed side of the seal assembly; 2) penetrating items which represent a large thermal mass generally create a more severe thermal challenge to penetration sealant materials than do items with a smaller thermal mass (e.g., large fill of instrumentation cables; and 3) the smaller the annular space between the steel liner and penetrating power (high thermal mass) cables, the more heat will be transferred into the silicone sealant material, thus accelerating its thermal degradation at the cable seal interface.

The concerns associated with these principles are demonstrated by the results of the following tests which were judged by the staff to be the closest representation of the "as-built" plant conditions:

a. Construction Technology Laboratories Fire Test ICO1091035, "Fire and Hose Stream Tests for Penetration Seal Systems," dated October 1990.

   PSS1 was a 24-inch x 24-inch blockout which was subdivided into two 12-inch x 24-inch cable tray slots. The upper slot was penetrated by a 4-inch x 18-inch solid bottom cable tray and the lower slot by a 4-inch x 18-inch ladder back cable tray. Both trays had 100-percent cable fills and were filled with 8-3/4 inches of silicone foam (Density 23.7 lb/ft3) and 1-inch-thick ceramic fiber damming board was installed over each face of the penetration opening. The ladder back type cable tray was less restrictive to the free burning of the cables during the test and its mass and cross sectional area was less, thus reducing its ability to transfer heat by conduction from the fire through the penetration seal system and dissipate it on the unexposed side of the fire test slab. This test assembly exceeded the thermal acceptance criteria required by the test plan. When compared to the results of a solid bottom tray, the

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* CTP-IOO1A, 'Three Hour Fire Qualification Test, 10' and 68 Depth Silicone RTV Foam for Electrical and Mechanical Penetration Seals," dated July 25, 1980.

Construction Technology Laboratories Fire Test 1CC0386017, 'Fire and Hose Stream Test For Penetration Seal Systems (NMP2-PSS8)," dated April 1986.

Construction Technology Laboratories Fire Test IC01091035, 'Fire and Hose Stream Tests for Penetration Seal Systems,* dated October 1990.

power cable penetration seal interface temperatures of the ladder back tray configuration were approximately 180 °F (82 °C) greater than those in the solid bottom cable tray configuration.

PSS8 was a 8-inch x 24-inch blockout penetrated by a 4-inch x 18-inch solid bottom cable tray. This tray had a 100% cable fill and was filled with 9 inches of silicone foam (Density 21.3 lb/ft3) and 1-inch-thick ceramic fiber damming board was installed on the exposed side of the test specimen. This test assembly exceeded the thermal acceptance criteria required by the test plan. The data from this test supports the theory that the thermal mass of the penetrant in relation to the size of the penetration opening has a pivotal impact on the thermal performance of the penetration seal.

b. Construction Technology Laboratories Fire Test IC1182009, "Fire and Hose Stream Tests for Penetration Seal Systems and Seismic Gap," dated December 1982.

PSS2 was a 8-inch x 28-inch blockout penetrated by a 6-inch x 24-inch ladder back cable tray. This tray was positioned in the blockout with its bottom and one side flush up against the sides of the blockout. The tray had a 100% cable fill and was filled with 9 inches of silicone foam (Density 17.1 lb/ft3) and 1-inch-thick ceramic fiber damming board was installed on the exposed side of the test specimen. This test assembly experienced burnthrough. This test confirms the theory that the thermal mass of the penetrant in relation to the size of the penetration opening can have a critical impact on the fire resistive characteristics of the penetration seal.

As result of NRC concerns related to the fire endurance qualification testing of cable slot type fire barrier penetration seals at Watts Bar, the applicant committed to perform plant specific testing of these seals.

During the week of October 16, 1995, at Omega Point Laboratories (OPL), Elmendorf, Texas, the applicant constructed the cable slot penetration seal test specimens. The test assembly consists of a 8-inch x 13-foot x 12-inch-thick concrete test slab with fourteen 5-inch x 20-inch cable slots penetrating the slab. On one half of the test slab, 8 cable tray slots (specimens A1 through A6 with varying control and instrumentation cable fill; specimens A7 and A8 were spare slots with no cable fill) were arranged in two parallel columns with 4 cable slots in each column. The slots in each column were separated by a 7-inch- wide concrete mullion and a 6-inch concrete mullion exists between the cable slot ends between the columns. The two cable slot columns were constructed so that they were maintained at least 24 inches away from the edge of the test slab. The remaining 6 cable slots (B1 through B6 with varying power cable fill) were located on the second half of the slab and were arranged in two parallel columns with 3 slots in each column. The columns were separated by a 6-inch-wide concrete mullion and each cable slot within each column was separated by a 7-inch-wide concrete mullion. These two cable slot columns were constructed so that the edges of cable slot columns were maintained at least 24 inches away from the edge of the test slab.

In addition, to address the staff concerns related to the combustibility of the cables used at Watts Bar, the applicant used plant-specific cables to construct the test specimens. The following summarizes the cable fill of each cable slot test specimen:

- Penetration Seal (PS) Test Specimen A1 - single layer of 4/c-#16 (43 cables)
- PS Test Specimen A2 - 100% visual fill of 4/c-#16 (230 cables)
- PS Test Specimen A3 - 100% visual fill of 4/c-#16 (230 cables)
- PS Test Specimen A4 - 50% visual fill of 4/c-#16 (150 cables)
- PS Test Specimen A5 - 50% visual fill of 4/c-#16 (150 cables)
- PS Test Specimen A6 - single layer of 4/c-#16 (43 cables)
- PS Test Specimen A7 - spare
- PS Test Specimen A8 - spare
- PS Test Specimen B1 - contains 300MCM (14 cables), 2/0-600v (3 cables), 2/0-8Kv (9 cables), 4/0 (2 cables), #2 (2 cables), #6 (4 cables), 3/c-#10 PXMJ (8 cables), and 3/c-#10 CPJJ (3-cables)
- PS Test Specimen B2 - contains 300MCM (9 cables)
- PS Test Specimen B3 - contains 300MCM (7 cables), 2/0-8Kv (3 cables), 4/0 (4 cables), #2 (1 cables), #6 (2 cables), 3/c-#10 PXMJ (10 cables), and 3/c-#10 CPJJ (6-cables)
- PS Test Specimen B4 - contains 300MCM (20 cables), 2/0 (12 cables), 4/0 (4 cables), #2 (2 cables), #6 (4 cables), 3/c-#10 PXMJ (14 cables), and 3/c-#10 CPJJ (6-cables)
- PS Test Specimen B5 - contains 300MCM (9 cables)
- PS Test Specimen B6 - contains 300MCM (7 cables), 2/0-8Kv (3 cables), 4/0 (4 cables), #2 (1 cables), #6 (2 cables), 3/c-#10 PXMJ (10 cables), and 3/c-#10 CPJJ (6-cables)

For specimens A1 through A6, each seal was constructed by installing damming board (Carborundum Fiberfax 1-in thick low density board) on the exposed (fire) surface of the specimen and filling the blockout void with 12 inches of silicone foam and was flush with the surface of the concrete. Once the foam had been injected into the blockout void, a damming board was installed on the unexposed surface of the slab.

Specimens A7 and A8 were spare penetrations with a 4-inch sleeve extension on each side of the concrete test slab. On the exposed (fire) side of A7 the damming board was attached to the end of the sleeve and 11-inch foam fill was injected into the cable slot blockout, thus creating a 9-inch air gap between the damming board and the foam on the unexposed side of the seal. Specimen A8 was constructed in the same manner, except that the 9-inch air gap was on the exposed (fire) side of the seal.

On the exposed (fire) side of PS test specimens B1 through B6, a damming board was installed and 11 inches (thickness) of silicone foam was injected into the blockout to fill the void. On the unexposed side, 1-inch thickness of ceramic fiber (Carborundum Durablanket) was installed between the foam seal and the outer damming board on the unexposed surface.

On October 22, 1995, the concrete test slab, containing the 14 cable slot penetration seal test specimens, was subjected to a 3-hour fire endurance test which followed the ASTM E-119 standard time-temperature curve and a fog hose stream test. The acceptance criteria of IEEE 634-1978, "Standard Cable Penetration Fire Stop Qualification Test," were used to evaluate the thermal/fire resistive performance of the test specimens. These criteria require the test specimen to withstand the fire endurance test without the passage of flame or gases hot hot enough to ignite cables on its unexposed side. They also require that heat transmission through the penetration seal not raise the temperature on its unexposed surface above 700 °F (371 °C) and not allow water to be projected through the penetration seal during the hose stream test.

All test specimens met the IEEE 634 acceptance criteria. The maximum unexposed cable/seal interface temperatures ranged from 323 °F (162 °C) for instrument and control cables to 601 °F (316 °C) for power cables.

The staff, based on the results of the applicant's supplemental cable slot fire endurance tests, finds those "as-built" penetrations which have been installed in accordance with Watts Bar cable slot penetration seal design details A4, H1, L1, and M4 and that are bounded by the tested cable fill (thermal mass of copper conductors) conditions will provide an equivalent level of fire safety to those which were tested. Therefore, they are acceptable.

Extrapolation of Test Data to 2-Hour Fire-rated Cable Slots

Penetrations A8158, A8159, A8160, A8162, A8163, A8164, and A13809 (Watts Bar Typical Detail H1) are 2-hour fire-rated seals for 5-inch x 20-inch cable slots. These penetrations are filled with 8 inches (minimum foam depth) of silicone foam and have permanent 1-inch-thick ceramic fiber damming boards installed over the penetration opening on both sides. These damming boards are cut and fitted to allow the penetrating cables to pass through them.

The staff compared the design of these seals to the tested configurations referenced by the applicant's engineering report.

Fire Test ICO1091035, PSS8 was an 8-inch x 24-inch blockout penetrated by a 4-inch x 18-inch solid bottom cable tray. This tray had a 100% cable fill and was filled with 9 inches of silicone foam (Density 21.3 lb/ft3) and 1-inch-thick ceramic fiber damming board was installed on the exposed side of the test specimen and was exposed to a standard time temperature test fire for 3 hours. Even though this test assembly exceeded the thermal acceptance criteria required by the test plan, it demonstrated that a 9-inch fill depth of foam, under similar conditions, was capable of preventing the passage of flame through the seal. Based on the results of this test, the minimum 8-inch fill depth, and the required 2-hour fire rating for these penetrations, the staff has reasonable assurance that these seals will adequately perform their intended design function and prevent the spread of fire from one plant area to another. Therefore, these seals are acceptable.

Evaluation of Watts Bar Penetration Seals not Bounded by Tested Configurations

There are approximately 5230 mechanical penetration seals installed at Watts Bar and approximately 96 percent of these seals have been designed and installed in accordance with the typical design details in Engineering Report

0006-00922-02, Revision 0 and are supported by adequate qualification testing. The remaining 4 percent (221 penetrations) were designed and installed using Watts Bar typical design details; however, because one or more of the bounding parameters defined by the design detail was exceeded, the applicant was required to perform additional engineering evaluations* which either addressed the adequacy of the seal as designed or its adequacy to perform its intended function based on the fire hazards and the fire protection features in the area.

The following is a summary of the 221 mechanical penetration seals for which the applicant performed additional engineering evaluations: 1) 125 penetrations that contained pipes larger than the size allowed by the typical detail; 2) 77 penetrations that contained pipes 2 inches greater in diameter sealed using a 2-layer boot assembly on each side of the penetration; 3) 7 penetration seals where spare sleeves exceed the maximum diameter allowed by the typical detail; and 4) 12 penetrations which had an annulus that exceeded the typical details. The following is the staff's audit of the applicant's engineering evaluations by design detail and Watts Bar penetration seal identification mark numbers:

Category A - Two-Layer Boot Seals With Penetrants Larger Than 2-Inch Diameter

Typical Details L, LXIV, and XLVIII

Watts Bar penetration seal Typical Details L, LXVI, and XLVIII are dual layer boot assemblies and are installed on both sides of the penetration and when tested (refer to Fire Test ICC0186015) survived the 3-hour ASTM E-119 standard fire test and hose stream exposure without the passage of flame, hot gases, or a water projection through the seal. The inner boot layer is Carborundum 36-400U Fibersil Cloth and the outer layer is Silicone Boot Arlon (KFC) grade 56493F031. The tested configuration had a maximum 5-inch annular space between the sleeve and penetrating item. Therefore, it is expected that those seals designed to Watts Bar Typical Details L, LXIV, XLVIII and that do not exceed the annular limitations will have an equivalent fire resistive performance to that of the tested configuration.

Penetrations R1S063, R1S064, R1S065, R1S066, R1S067, R1S068, and R1S070 are boot type seals (Watts Bar Typical Detail LXIV) that exceed the 5-inch annular limitations established by the tested configuration. Penetrations R1S063, R1S064, R1S065, and R1S066 are 66-inch-diameter pipe sleeves each with a 52- inch pipe penetrant and penetrations R1S067, R1S068, and R1S070 are 40-inch pipe sleeves each with a 30-inch pipe penetrant. These penetrations are installed in 3-hour fire barriers. Penetrations R1SO63, R1S066, R1S067 and R1S070 are installed in the fire barrier separating the south main steam valve room (Room A501) from the Annulus (Room R150) and penetrations R1S064, R1S065,

* Refer to Generic Letter 86-10, Appendix R Interpretation 4, Fire Area Boundaries. This interpretation states: "Where fire area boundaries are not wall-to-wall-, floor-to-ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, licensees must perform an evaluation to assess the adequacy of fire boundaries in their plants to determine if the boundaries will withstand the hazards associated with the area."

and R1S068 are installed in the fire barrier separating the north main steam valve room (Room A502) from the Annulus (Room R150). The plant fire protection associated with Rooms A501 and A502 consists of automatic thermal fire detection and manual fire fighting equipment (portable fire extinguishers and hose stations in adjacent area). Plant fire protection in the annulus consists of automatic fire suppression and detection provided for cable interactions and exposed cable concentrations.

The annular space for these penetrations exceeds the tested limitation by 3/8 of an inch to 2-3/4 inches. Since these are boot seals and they are mechanically attached to both the pipe and the sleeve assembly on both sides of the penetration, it is not expected that this minimal increase in the annular space dimension will have an impact on the fire rating of these seals. The staff, based on the "as-built" design of these seals and the plant fire protection features provided in the area of these seals, has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, are acceptable.

<u>Category B - Foam Seals With Fluid Filled Large Bore Pipe</u>

Typical Detail I, V, VIII, and XL

The penetration seal assemblies identified in table 3.1.4.1 (a) use Watts Bar Typical Details I, V, VIII, and XL as their design basis. All of these seals are pipe sleeve type penetration and use silicone foam material (density range of 15-30 lb/ft3) to seal annular space between the penetration sleeve and the pipe/conduit penetrant(s) and are required to have a minimum foam fill depth of 12 inches however, they exceed the sleeve size limitations qualified by test.

The staff reviewed the "as-built" design parameters of the penetration seal assemblies identified in table 3.1.4.1 (a) and compared them to Fire Test 93-H-72449, Penetration 11. This test demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 16-inch-diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of silicone foam can resist the passage of flame through the penetration for specified 3-hour fire test duration. The depth of the silicone foam in the table 3.1.4.1 (a) seals exceed the seal depth of the tested configurations from 1 to 42 inches. In addition, the required fire-rating of these seals is 2 hours which is less than the 3-hour rating of the tested configuration and the CrF (0.7 to 0.85) of these seals did not deviate significantly from the CrF (0.79) of the tested configuration.

Based on the "as-built" design parameters of these seals and their required fire resistive rating (2-hours), the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, are acceptable.

<u>Category C - Elastomer Seals With Fluid Filled Large Bore Pipe</u>

Typical Detail LX, LXI, XLII, XLIV, and XLVI

The penetration seal assemblies identified in table 3.1.4.1 (b) use Watts Bar Typical Details LX, LXI, XLII, XLIV and XLVI as their design basis. All of these penetrations are pipe sleeve type and they use MDSE material (density range of 76-87.2 lb/ft3). The penetration annular space between the penetration sleeve and the pipe/conduit penetrant is filled with MDSE to a minimum depth of 6 inches. However, they exceed the sleeve size limitations qualified by test.

The staff reviewed the "as-built" design parameters of the penetration seal assemblies identified in table 3.1.4.1 (b) and compared them to Fire Test 93-H-72449, Penetration 7. This test demonstrated that a 12-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with an 8-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 6 inches (depth of seal material) of MDSE and dammed with 1-inch ceramic fiber board can resist the passage of flame through the penetration for specified 3-hour fire test duration. The depth of the MDSE in the table 3.1.4.1 (b) seals exceed the seal depth of the tested configurations from 1/2 to 18 inches. In addition, the required fire-rating of these seals is 2-hours (except for penetrations DG0001, DG0002, DG0003, and DG0004 are 3-hour rated) which is less than the 3-hour rating of the tested configuration.

Based on the "as-built" design parameters of these seals and their required fire resistive rating (2-hour and 3-hour penetrations DG0001, DG0002, DG0003, and DG0004), the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail XLVII

Penetration A2186AM is a 42-inch-diameter sleeve is a HDSE seals with a 36- inch pipe penetrant installed in a 3-hour fire barrier. This seal is filled with 15 inches of HDSE material (density range of 150-173.5 lb/ft3). The "as-built" 36-inch pipe penetrant is filled with water. Fire Tests CTP 1124, penetration 1.c., tested a 36-inch-diameter pipe sleeve penetrated by a 10- inch-diameter water-filled pipe. This penetration was sealed with Promatec PROMAFLEX and 1-inch-thick Alumina Silica damming board. This test demonstrated that pipes filled with a liquid that the seal surface pipe interface was approximately 486 °F (252 °C) cooler than a seal not filled by a liquid. Fire Test 93-H-72449, Penetration 8, qualified a 26-inch-diameter steel pipe sleeve penetration in a 12-inch-thick concrete slab with an 18-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of HDSE as an effective 3-hour fire-rated design.

Based on these test results, the staff has reasonable assurance that the "as-built" design parameters will adequately prevent the spread of fire from one plant area to another and, therefore, are acceptable.

Category D - Single-Sided Boot Seals

Typical Detail LXI

Penetration R1S062 is a single side boot type penetration seal. This penetration ia 16-inch-diameter sleeve with a 12-inch pipe penetrant in a 3-hour fire barrier. The inner boot layer is 1-layer of silicone boot Arlon (KCF) grade 56493F031 and Carborundum 36-400U Fibersil Cloth, then 3-layers of Carborundum Durablanket, and an outer boot of 1-layer of Carborundum 36-400U Fibersil Cloth and 1-layer of silicone boot Arlon (KCF) grade 56493F031. ICMS Test ICC1088024, Penetration 2 tested the same basic configuration. The test specimen met the 3-hour acceptance criteria and did not allow the passage of flame or projection water through to the unexposed side of the seal. Based on these test, the staff has reasonable assurance that this penetration seal will prevent the spread of fire from one plant area to another and, therefore, is acceptable.

Category E - Installation specific seal evaluations

Typical Details C9 and N3

Penetration R1S008 (Typical Detail C9) is a 16-inch-diameter spare sleeve (no penetrating items) through a 3-hour fire barrier. This penetration is filled with 12 inches of silicone foam and it has a steel plate bolted to and covering one side of the penetration opening. Penetration R1S007 (Typical Detail N3) is a 16-inch-diameter spare sleeve (no penetrating items) through a 3-hour fire barrier. This penetrations is filled with 12 inches of silicone foam and it has a 1/2-inch steel plate welded on both sides to cover the penetration openings.

Penetration R1S020 (Typical Detail N3) is a 24-inch-diameter spare sleeve (no penetrating items) through a 3-hour fire barrier. This penetration is filled with 12 inches of silicone foam and it has a 1/2-inch steel plate welded on both sides to cover the penetration openings.

Penetrations R1S007 and R1S008 are located in the 3-hour fire barrier separating the Reverse Osmosis Room (Room A810) and the Containment Annulus (Room R150) and automatic detection and sprinkler protection is provided on both sides of this wall. These penetrations are filled with 12 inches of silicone foam which when tested provided the required 3-hour fire resistance in a 14-inch-diameter spare sleeve. In addition, these penetrations have a steel plate covering one or both sides of their through-wall openings.

Penetration R1S020 is located in the 3-hour fire barrier separating the Ventilation Purge Air Room (Room A705) and Containment Annulus (Room R150) and automatic detection and sprinkler protection is provided on both sides of this wall. This penetration is filled with 12 inches of silicone foam which, when tested provided the required 3-hour fire resistance in a 14-inch-diameter spare sleeve. In addition, this penetration has a steel plate covering both sides of its through-wall openings.

Based on the design of these seals and the fire protection features provided for the plant areas on either side of the affected fire barrier, the staff has reasonable assurance that these penetration seals will provided an adequate level of fire safety, thus preventing the spread of fire from one plant area to another. Therefore, they are acceptable.

Typical Detail I

Penetration A0776AM, an 18-inch-diameter sleeve with a 1-inch-diameter pipe penetrant filled with 12 inches of silicone foam, is located in the 3-hour fire barrier separating the Heating and Ventilation Room (Room A712) and Corridor (Room A701). Automatic detection is provided on both sides of the wall and sprinkler protection is provided in corridor A701. This same basic type of penetration when tested provided the required 3-hour fire resistance in a 14-inch-diameter spare sleeve. In addition, the applicant in its engineering report technically justified Detail I type penetrations with a 14-inch-diameter (or smaller) pipe sleeve installed in a 12-inch-thick (minimum) concrete slab with either a single or multiple penetrants (pipes or conduits) filled with a minimum 12 inches of silicone foam and having a CrF ranging from 0.16 to 0.66 and a 20-inch-diameter pipe sleeve with a single pipe penetrant and filled with a minimum of 12 inches of silicone foam having a CrF of 0.79. Penetration A0776AM has a CrF of 0.05, which is less than the CrF range supported by the Detail I tested configurations; therefore, it can be expected that this seal would provide the same level of fire safety as that of the tested configuration. Based on plant fire protection features provided in the area of this seal and the adequacy of the seal design, the staff has reasonable assurance that this penetration seal will prevent the spread of fire from one plant area to another and, therefore, it is acceptable.

Penetrations A0970AM, A0970BM, A0971AM and A0971BM are foam seals in 2-hour fire barriers. These penetrations are a 22-inch-diameter sleeve with a 20- inch pipe penetrant. Penetrations A0970AM and A0971AM are filled with 18 inches of foam and penetrations A0970BM and A0971BM are filled with 17 inches of foam.

Fire Test 93-H-72449, Penetration 11, demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12 inch thick concrete slab with a 16-inch- diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of silicone foam can resist the passage of flame through the penetration for specified 3-hour fire test duration.

The "as-built" sleeve diameter is 2 inches greater in diameter than the tested configuration with a penetrant which is 4 inches greater, thus resulting in a condition which is more severe than the tested configuration. However, this is conservatively compensated for by the 5 inches (minimum) greater in foam depth and reduction in required fire-rating (2 hours). Based on "as-built" design parameters of these seals and the 2-hour fire-rating requirement, the staff has reasonable assurance that these seals will adequately prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail VIII

Penetration A1469AM is an 18-inch pipe sleeve type penetration with a 16-inch pipe penetrant. This penetration is installed in a 3-hour fire barrier which separates pipe gallery (Room A307 and Unit 1 pipe gallery (Room A406) and is filled with 11-5/8 inches of silicone foam within the barrier and 3-7/8 of additional silicone foam in the sleeve extension on the top side of the barrier. The plant fire protection features in the area of this penetration seal consists of automatic detection and sprinkler protection.

The staff reviewed the "as-built" design parameters of this penetration seal and compared it to Fire Test 93-H-72449, Penetration 11. This test demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12-inch- thick concrete slab with a 16-inch-diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of silicone foam can resist the passage of flame through the penetration for specified 3-hour fire test duration. The depth of the silicone foam in penetration A1469AM exceeds the seal depth of the tested configurations by 3-1/2 inches.

Based on the "as-built" design parameters of penetration A1469AM and the plant fire protection features in the area of this seal, the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail XXXII

Penetration A0008AM is a 26-inch-diameter sleeve with a 11-1/4-inch intermediate sleeve with a 10-inch pipe penetrant in a 2-hour fire barrier separating containment spray pump 1B-B room (Room A208) and pipe gallery (Room A216). The 26-inch-diameter sleeve is filled with 46 inches of HDSE and the 10-inch pipe penetrating the 11-1/4-inch intermediate sleeve is sealed with a 2-layer boot assembly on both sides of the wall. The fire protection features in the area of the seal are automatic fire detection and manual fire fighting equipment (i.e., portable fire extinguishers and hose stations).

Fire Test 93-H-72449, Penetration 8 qualified a 26-inch-diameter steel pipe sleeve penetration in a 12-inch-thick concrete slab with an 18-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of HDSE as an effective 3-hour fire-rated design. Penetration A0008AM has a CrF of 0.40 which is less than the CrF (0.79) of the tested assembly. Based on the "as-built" design of this seal (penetration filled with a 46-inch depth of HDSE) and the required fire resistive rating (2-hours), the staff has reasonable assurance that this penetration seal will prevent the spread of fire from one plant area to another and, therefore, it is acceptable.

Typical Detail XXXVIII, XLVI, and XLII

Penetration A0766AM (Watts Bar Typical Detail XLVI) and Penetration A0766BM and A0766CM (typical detail XLII) are 40-inch-diameter pipe sleeves each with a 24-inch pipe penetrant. These penetrations are installed in the 12-thick concrete 2-hour fire barrier separating corridor (Room A701) from auxiliary building corridor (A401) and each penetration is filled with 10 inches of MDSE. Both sides of the barrier are protected by automatic sprinklers and an ionization smoke detection system.

Penetration A0457BM (Watts Bar Typical Detail XLVI) is a 20-inch-diameter pipe sleeve with three 2-inch-diameter pipe penetrants. This penetration is installed in a 12-inch-thick concrete 2-hour fire barrier separating Unit 1 pipe gallery (Room A406) and pipe gallery (Room A307) and is filled with 7 inches of MDSE. Both sides of this barrier are protected by automatic sprinklers and an ionization smoke detection system.

Penetrations C0001A, A0777AM, and A0463BM (Watts Bar Typical Detail XXXVIII) are 18-inch-diameter pipe sleeves with no penetrating items. Penetration C0001A and A0777AM are filled with 7 inches of MDSE and Penetration A0463BM is filled with 11 inches of MDSE. Penetration C0001A is installed in a 3-hour fire barrier separating the Turbine Building (Room T201) and Auxiliary Building Corridor (Room A401). Penetrations A0777AM and A0463BM are installed in 2-hour fire barriers. The fire barrier in which Penetration A0777AM is installed, separates Heating Ventilation Room (Room A712) from Auxiliary Building Corridor (Room A401). Penetration A0463AM is installed in the fire barrier separating Heat Exchanger 1-B Room (Room A411) and Heat Exchanger 1-A Room (Room A412).

Fire Test ICC0286018, qualified a 30-inch x 30-inch blockout with three penetrating items filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab as an effective 3-hour fire-rated design. This blockout tested a maximum unsupported free area of 17 inches x 30 inches (510 in2). The tested configuration consisted of a 6-inch depth of silicone elastomer with no damming. The installed configurations each have a minimum of 6 inches of silicone elastomer in the barrier with an additional 4 inches of elastomer in the sleeve extension on the top side of the penetration. Since the 3-hour rated configuration with 6 inches foam was structurally stable, Penetration A0463BM with 11 inches, Penetrations A0766AM, A0766BM and A0766CM with 10 inches, and Penetrations C0001A, A0463BM, and A0457BM with 7 inches of elastomer are expected to maintain their structural integrity and maintain the fire resistance required by their respective fire barriers. Based on the "as-built" design of these seals, their required fire resistive rating (2 hours), and the plant fire protection features provided in the area of these seals, the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail XLVI - Deviations from 3-Hour Designs

The penetration seal assemblies identified in the table below use Watts Bar Typical Details XLVI as their design basis. All of these penetrations are pipe sleeve type and they use MDSE material (density range of 76-87.2 lb/ft3) and are installed in 3-hour fire barriers. The penetration annular space between the penetration sleeve and the pipe/conduit penetrant is filled with MDSE to a minimum depth of 6 inches. However, they exceed the sleeve size limitations qualified by test.

PENETRATION ID	SLEEVE DIA	PENETRANT DIA	ELASTOMER DEPTH
A0956CM	18"	12"	13"
A0956DM	18"	12"	13"
A1109AM	12"	8"	14"
A1110AM	12"	8"	14"
A0968AM	12"	8"	12"
A1035CM	14"	8"	11"
A1806AM	16"	12"	12"
A1807AM	12"	8"	12"
C0012A	12"	8"	13"
A1893AM	18"	16"	12"
A1901AM	18"	16"	12"

The staff reviewed the "as-built" design parameters of the penetration seal assemblies identified in table and compared them to Fire Test 93-H-72449, Penetration 12. This test demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 16-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of MDSE can resist the passage of flame through the penetration for specified 3-hour fire test duration. The CrF of this tested configuration is 0.79 and the "as-built" conditions identified in the table above have a CrF ranging from 0.57 to 0.88. The staff's review of Fire Test 93-H-72449 revealed that the test specimen passed the fire endurance test with margin. Therefore, it can be expected that Penetrations A1893AM and A1901AM (which exceed the tested configuration CrF) will adequately perform their fire resistive function.

Based on the "as-built" design parameters of these seals, the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail XLVI - Deviations from 2-Hour Designs

The penetration seal assemblies identified in the table below use Watts Bar Typical Details XLVI as their design basis. All of these penetrations are pipe sleeve type and they use MDSE material (density range of 76-87.2 lb/ft3) and are installed in 2-hour fire barriers. The penetration annular space between the penetration sleeve and the pipe/conduit penetrant is filled with

MDSE to a minimum depth of 6 inches. However, they exceed the sleeve size limitations qualified by test.

PENETRATION ID	SLEEVE DIA	PENETRANT DIA.	ELASTOMER DEPTH
A0920BM	24"	22"	11"
A0920DM	24"	22"	27"
C0067A	12"	8"	7"
C0068A	12"	8"	8"
A1109BM	12"	8"	7"
A0929AM	12"	8"	9"
A0929BM	12"	8"	9"
A0967AM	12"	8"	11"
A0967BM	12"	8"	11"
A1035BM	14"	8"	10"

The staff reviewed the "as-built" design parameters of the penetration seal assemblies identified in table and compared them to Fire Test 93-H-72449, Penetration 12. This test demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 16-inch-diameter pipe penetrating the sleeve and the 4-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of MDSE can resist the passage of flame through the penetration for specified 3-hour fire test duration.

In addition, the staff compared these "as-built" penetration seal designs to Construction Technology Laboratories Fire Test ICC0186015, "Fire and hose Stream Test for Penetration Seal Systems," dated March 1986. Specifically, the test of Penetration 3 which demonstrated that a 12-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 2-
inch-diameter pipe penetrating the sleeve and the-5 inch annular space between the pipe and the sleeve filled with 6 inches (depth of seal material) of MDSE can resist the passage of flame through the penetration for specified 3-hour fire test duration.

Using the thermal data from these tests, a general extrapolation can be made which would support a minimum 8-1/2-inch MDSE fill depth is needed in the annular space between the 12-inch pipe sleeve and the 8-inch penetrating item for a 3-hour fire rating.

Therefore, based on the "as-built" design parameters of these seals and their required fire resistive rating (2 hours), the staff has reasonable assurance that these penetration seals will prevent the spread of fire from one plant area to another and, therefore, they are acceptable.

Typical Detail LXXXIII

Penetration A1880AM is a foam seal in a 3-hour fire barrier. This penetration is an 18-inch-diameter sleeve with a 16-inch pipe penetrant and is filled with 17-1/2 inches of foam. The fire barrier separates the Upper Head Injection Equipment Room (Room E101) and nitrogen Storage Area (Room A506). These plant areas are provided with manual fire fighting equipment and automatic fire detection capability.

Fire Test 93-H-72449, Penetration 11 demonstrated that a 20-inch-diameter steel pipe sleeve penetrating a 12-inch-thick concrete slab with a 16-inch- diameter pipe penetrating the sleeve and the 2-inch annular space between the pipe and the sleeve filled with 12 inches (depth of seal material) of silicone foam can resist the passage of flame through the penetration for specified 3-hour fire test duration.

The "as-built" sleeve diameter is 2 inches smaller in diameter than the tested configuration with a penetrant which is equal to that which was tested, resulting in a condition which is more severe than the tested configuration. However, this is conservatively compensated for by the 5-1/2 inches of additional foam depth. Based on "as-built" design parameters and the plant fire protection features in the area of this seal, the staff has reasonable assurance that it will adequately prevent the spread of fire from one plant area to another. Therefore, it is acceptable.

Category F - Large Annulus Spare Sleeves

Typical Detail III, XXXVIII

Penetration A0463AM (Watts Bar Typical Detail III) is an 18-inch-diameter spare pipe sleeve (with no penetrants) filled with a minimum of 12 inches of silicone foam in a 2-hour fire barrier. Fire Test ICC1091035, Penetration 3 qualified a 14-inch-diameter steel pipe sleeve penetration filled with 12 inches (depth of seal material) of silicone foam in a 12-inch-thick concrete slab with no penetrating items as an effective 3-hour fire-rated design. This penetration exceeds the free area limitations of this test. However, based on the similarity in design to the tested 3-hour fire-rated configuration and its required 2-hour fire rating, the staff has reasonable assurance that it will adequately perform its intended design function and prevent the spread of fire from one plant area to another. Therefore, the staff finds this penetration acceptable.

Penetrations A0463BM, A0777AM, and COO1A (Watts Bar Typical Detail XXXVIII) are 18-inch-diameter spare pipe sleeves with no penetrants filled with a minimum of 6 inches of MDSE. However, Fire Test ICC1185020 qualified a 30-inch x 30-inch blockout with three penetrating items filled with 6 inches (depth of seal material) of MDSE in a 12-inch-thick concrete slab as an effective 3-hour fire-rated design. This blockout tested a maximum unsupported free area of 17 inches x 30 inches (510 in2). The free area of the tested configuration exceeds the free area of the 18-inch sleeve by 256 in2. Therefore, it is expected that a fire would not structurally degrade the integrity of the silicone foam seal in the 18-inch sleeve. Based on this, the staff has reasonable assurance that Penetrations A0463BM, A0777AM, and COO1A will adequately perform their intended design function and prevent the spread of fire from one plant area to another and, therefore, these penetrations are acceptable.

The staff concludes from its audit of the applicant's penetration seal program that this program adequately demonstrates the fire resistive rating of these typical penetration seal designs and, therefore, they conform to the guidelines of Positions D.1.j and D.3.d of Appendix A to BTP (APCSB) 9.5-1 and are acceptable.

~~3.2 Safe Shutdown Capability~~

~~3.2.1 Separation of Safe Shutdown Functions~~

~~In SSER 18, the staff indicated that for safe shutdown components located inside the containment building, the applicant would use one of the means specified above, or one of the following means to achieve separation between trains:~~

~~(1) Automatic fire detection and suppression installed in the area~~
~~(2) Separation of equipment, components, and associated circuits of redundant systems by a radiant energy shield (refer to SER Section 6.0, Deviations, Combustibility of Radiant Energy Heat Shields).~~

~~In addition to the separation method specified above, the applicant has provided 20 feet or more of horizontal spatial separation, which is void of intervening combustibles or fire hazard, between redundant safe shutdown functions inside containment.~~

~~The staff concludes that these methods satisfy the technical requirements of Appendix R, Section III.G, "Fire Protection of Safe Shutdown Capability," and, therefore, are acceptable.~~

~~3.8 Smoke Control and Ventilation~~

~~In SSER 18, the staff indicated that where smoke is ducted to other rooms, the normal ventilation rates or the natural vent openings in these rooms are sufficient to prevent smoke from stratifying or excessively concentrating in the rooms. The smoke will be removed from these rooms directly to the outside. When fixed ventilation equipment is used for the removal of smoke, all necessary equipment and cabling from the fire area are separated by 1 1/2-hour fire-rated barriers. However, the actual "as-built" conditions assure that all necessary equipment and cabling are separated from the area affected by the fire by minimum 1-hour fire barrier.~~

~~The staff concludes that these "as-built" conditions do not affect the applicant's smoke removal concept and are, therefore, acceptable.~~

~~4.0 FIRE PROTECTION SYSTEMS~~

~~4.2 Active Fire Control and Suppression Features~~

~~4.2.1 Automatic Fire Suppression Systems~~

~~4.2.1.1 Sprinklers and Fixed Spray Systems With Closed Heads~~

~~Fixed water spray systems and sprinkler systems are designed in accordance with the applicable requirements of National Fire Protection Association Standard No. 13-1975 (NFPA 13), "Standard for Installation of Sprinkler Systems," and NFPA 15-1973, "Standard for Water Spray Fixed System." In SSER 18, the staff evaluated the applicant's code compliance review. As a result of final plant walkdowns, the applicant in its November 1, 1995, submittal (Revision 5 of the Watts Bar Fire Protection Report) identified additional code deviations to NFPA 13, Sections 4-4.11 and 4-4.13. In this code deviation, the applicant identified the following plant locations that do not have sprinklers installed under gratings/platforms:~~

- ~~Room 692.0-A7 - grating located above High Pressure Fire Pump FCVs in the Unit 1 penetration room.~~
- ~~Room 757.0-A10 - grating located south of column line A4/W.~~
- ~~Room 737.0-A9 - grating located northwest of column A11/W.~~
- ~~Room 737.0-A12 - grating located between the exterior wall and the first bank of filters.~~
- ~~Room 737.0-A3 - grating located between the exterior wall and the first bank of filters.~~
- ~~Room 757.0-A2 - under the stairs~~
- ~~Room 757.0-A3 - under the stairs~~
- ~~Room 772.0-A9 - platform over the HEPA filters.~~

~~In addition, the applicant in its code deviation identified the following plant areas that do not have sprinklers installed under equipment spray shields:~~

- ~~Room 692.0-C10 - equipment spray shield over the chillers.~~
- ~~Room 737.0-A1 - equipment spray shields over the chillers 0-CHR-31-36/2, 0-CHR-31-96, and 0-CHR-31-80, radiation monitors 1-RE-90-112 and 1-RE-90-106, and the Unit 2 AFW pump steam generator level control valves (Sprinklers will need to be provided for the Unit 2 AFW pump steam generator level control valves prior to fuel load for this Unit)~~

~~During the week of October 30, 1995, the staff performed an on-site walkdown of these deviations and found that the lack of sprinkler protection under the above gratings/platforms and spray shields (installed to prevent damage to water-sensitive equipment in the event of an inadvertent actuation of the area sprinkler) acceptable deviations from NFPA 13 and that they will not affect the overall fire suppression system performance and the level of fire safety provided by these systems. Therefore, they are acceptable.~~

5.0 FIRE PROTECTION FOR SPECIFIC PLANT AREAS AND HAZARDS

5.2 Control Room Complex

5.2.1 Control Room

In SSER 18, the staff indicated that below the main control room consoles, a 3 ft X 4 ft access walkway extends approximately 4 ft down into the cable spreading room and that this walkway was separated from the cable spreading room by a 3-hour fire-related barrier. In addition, the staff stated that all the cabling enters the metal gutters from the spreading room cable tray system at the bottom of the enclosed raceway, passing through 3-hour fire-rated penetration seals. In actuality, this walkway is not separated from the cable spreading room by a 3-hour fire barrier and the 3-hour fire-rated penetration seals are not provided for the cabling entering the metal gutters.

The staff finds that this "as-built" condition does not affect the overall fire safety provided for the control room complex and is, therefore, acceptable.

~~5.3 Cable Spreading Room~~

~~In SSER 18, the staff indicated that the walls, floors, and ceiling or the cable spreading room are designed to have a fire rating of 3 hours. However, in actuality, the walls are rated for 3 hours, the floor is rated for 2-hours and portions of the ceiling are rated for 1-hour.~~

~~Based on the level of fire protection provided for the cable spreading room (refer to SSER 18), the staff concludes that these "as-built" fire barrier conditions do not affect the overall fire safety or impact the ability to achieve and maintain post-fire safe shutdown conditions and, therefore, are acceptable.~~

~~6.0 DEVIATIONS FROM STAFF FIRE PROTECTION GUIDANCE~~

~~6.7 Deviation - Emergency Lighting~~

~~Section III.J of Appendix R requires emergency lighting units with at least 8-hours battery power supply be provided in all areas needed for operation of safe shutdown equipment and in access and egress routes thereto.~~

~~The applicant in its November 1, 1995 submittal, revised its position with regard to emergency lighting for the containment annulus. The applicant has provided the required lighting in the containment annulus. However, inside the lower containment, the applicant has requested deviation from providing emergency lighting inside the lower containment. Manual actions requiring entry into the primary containment would only result from fire damage to the RHR isolation valves or the cables near these valves which are located in the lower containment. The re-alignment of these valves may be necessary as result of fire damage and can be performed anytime within four hours after the reactor is tripped. A fire affecting the RHR isolation valves could damage the lighting circuits in the immediate vicinity, but it would not disable all the lower containment lighting. In addition to normal plant lighting in this area there is diesel backed (standby) lighting located on three different elevations both inside and outside the crane wall. The staff reviewed the lighting circuits and their cable routings in the area of the lower containment and determined that the normal lighting and the standby lighting for the access and egress paths to the lower containment would not be affected by the fire.~~

~~The applicant claims that batteries for the 8-hour emergency lighting units can not be qualified for high temperature and humidity environment such as that experienced inside the primary containment. Due to ALARA concerns access into the primary containment during plant operations is very limited, which~~

~~means that inspection and testing of the battery units could only be done during an outage. The applicant has provided dedicated hand-held portable lighting units for use in supporting manual fire fighting and safe shutdown actions for fires in the lower containment.~~

~~Based on its review of the normal lighting and standby lighting in the lower containment, the staff concluded that adequate lighting exists for access and egress to the manual action sites and that dedicated hand-held portable lighting units for use in supporting manual fire fighting and safe shutdown actions are an acceptable deviation from the lighting criteria required by Section III.J, of Appendix R and, therefore, are acceptable.~~

~~6.9 Deviations - BTP 9.5-1, Appendix A~~

~~6.9.7 Fire Barrier Between Refueling Floor and Unit 2 Reactor Building~~

~~The applicant in its November 1, 1995 submittal, requested a deviation from Section D.1.j of Appendix A to APCSB BTP 9.5-1 for the fire barrier between the refueling floor and the Unit 2 Reactor Building. This section of Appendix A states, "Penetration in these fire barriers, including conduits and piping should be sealed or closed to provide a fire resistance rating at least equal to that of the fire barrier itself. The fire hazard in each area should be evaluated to determine the barrier requirements."~~

~~The fire barrier separating the Refueling floor from the Unit 2 Reactor Building is a 3-hour fire-rated barrier and it contains a non fire-rated equipment hatch door assembly. The equipment hatch door is closed by the blast doors and the overhead rolling door. The area between these doors is provided with an automatic detection and suppression system. For a fire inside the Unit 2 reactor building to propagate to the refueling floor, it would have to breach the steel blast doors, not be controlled by the automatic suppression system and breach the rolling steel door. The staff considers this type of fire scenario improbable and considers the level of existing fire protection to provide a level of fire safety equivalent to that specified by Section D.1.j of Appendix A to APCSB BTP 9.5-1 and, therefore, is acceptable.~~

TABLE 3.1.4.1 (a) CATEGORY B - FOAM SEALS WITH FLUID FILLED LARGE BORE PIPE				
PENETRATION ID	**SLEEVE DIA. (INCHES)**	**PENETRANT DIA. (INCHES)**	**SEAL DEPTH (INCHES)**	**FIRE-RATING**
A002BM	20	14	13	2
A002CM	20	14	13	2
A002DM	20	14	15	2
A0010BM	26	20	13	2
A0094AM	30	16	54	2
A0094BM	30	16	17	2
A0142BM	30	24	36	2
A0205AM	20	16	30	2
A0205BM	20	16	27	2
A0208BM	24	20	12	2
A0395BM	24	18	27	2
A0473CM	24	18	28	2
A0473DM	24	18	30	2
A0474BM	24	18	15	2
A0474DM	24	18	14	2
A0480BM	26	20	36	2
A0483AM	24	18	12	2
A0483BM	24	18	12	2
A0484BM	24	18	12	2
A0485AM	20	16	23	2
A0623AM	26	20	48	2
A0753AM	30	24	27	2
A0753BM	30	24	39	2
A0753CM	30	24	13	2
A0753DM	30	24	12	2
A0758CM	24	18	12	2
A0758DM	24	18	27	2

TABLE 3.1.4.1 (a) - CONTINUED CATEGORY B - FOAM SEALS WITH FLUID FILLED LARGE BORE PIPE				
PENETRATION ID	**SLEEVE DIA. (INCHES)**	**PENETRANT DIA. (INCHES)**	**SEAL DEPTH (INCHES)**	**FIRE-RATING**
A0765AM	24	18	12	2
A0765BM	24	18	17	2
A0807BM	24	18	36	2
A0808AM	24	18	36	2
A0808BM	24	18	21	2
A0816BM	24	18	30	2
A0817BM	24	18	30	2
A02140AM	42	36	27	2

TABLE 3.1.4.1 (b) CATEGORY C - ELASTOMER SEALS WITH FLUID FILLED LARGE BORE PIPE				
PENETRATION ID	SLEEVE DIA. (INCHES)	ELASTOMER-DEPTH (INCHES)	SEAL DEPTH (INCHES)	FIRE-RATING
A0002AM	20	14	6.5	2
A0263DM	16	12	12	2
A0472AM	20	16	24	2
A0486AM	24	18	12	2
A0486BM	24	18	12	2
A0486CM	24	18	12	2
A0486DM	24	18	18	2
A0486EM	24	18	10.5	2
A0486GM	24	18	12	2
A0484IM	24	18	12	2
A0657EM	10	8	9	2
A0657FM	10	8	11	2
A0657GM	10	8	12	2
A0657HM	10	8	10	2
A0752DM	30	24	12	2
A0758AM	24	18	12	2
A0760CM	20	16	12	2
A0760DM	20	16	6	2

TABLE 3.1.4.1 (b) - CONTINUED CATEGORY C - ELASTOMER SEALS WITH FLUID FILLED LARGE BORE PIPE				
PENETRATION ID	**SLEEVE DIA. (INCHES)**	**ELASTOMER-DEPTH (INCHES)**	**SEAL DEPTH (INCHES)**	**FIRE-RATING**
A0766AM	40	24	6	2
A0766BM	40	24	6	2
A0766CM	40	24	6	2
A0801AM	30	24	6	2
A0801BM	30	24	6	2
A0993AM	14	10	27	2
DG0001	14	10	7	3
DG0002	14	10	7	3
DG0003	14	10	7	3
DG0004	14	10	7	3

ENCLOSURE 5

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

SUPPLEMENTAL SAFETY EVALUATION REPORT 26 ANNOTATED

(Note that the layout of the text on the following pages of this enclosure depicts the text as it is in the SSER)

APPENDIX FF

FIRE PROTECTION PROGRAM SAFETY EVALUATION

WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2

1.0 INTRODUCTION

The Tennessee Valley Authority (TVA) is the licensee for Watts Bar Nuclear Plant (WBN) Unit 1 and is the applicant for an operating license for WBN Unit 2. TVA submitted the As-Designed Fire Protection Report (FPR) for WBN Units 1 and 2 to the U.S. Nuclear Regulatory Commission (NRC) by letter dated December 18, 2010, as revised and supplemented by letters dated December 20, 2010; January 14, March 16 and 31, May 6, 18, and 26, June 7 and 17, July 1 and 22, August 5 and 15, September 30, October 28, November 21 and 30, 2011; March 13, April 12, 17, and 26, May 9 and 30, June 7 and 27, July 19, September 13, December 20, 2012; February 7 and 28, and March 13, 2013. U1 U2

In the FPR, TVA stated that, "the purpose of the Fire Protection Report (FPR) is to consolidate a sufficiently detailed summary of the WBN regulatory required Fire Protection Program into a single document and to reflect the design as-constructed at the time of fuel load." The FPR describes the operational phase of the fire protection program. Accordingly, the NRC staff reviewed the entire fire protection program (except as noted otherwise) using the agency's fire protection requirements and review guidance. Because WBN consists of two units of identical design, this evaluation applies to the fire protection program for both WBN Unit1 and WBN Unit 2 (except as noted otherwise).

The NRC staff's review did not include Section 7, "Unit 1 Operator Manual Actions [OMAs]," of Part VII of the FPR. The NRC's approval of the WBN Unit 1 OMAs is documented in Supplemental Safety Evaluation Report (SSER) 18, NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2," dated October 1995. U1

TVA's fire protection program is required to comply with the following:

- General Design Criterion (GDC) 3, "Fire Protection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities"
- 10 CFR 50.48, "Fire Protection," paragraph (a),

In addition to these requirements, TVA commited in the FPR that its fire protection program has been developed to comply with, and is based on, the requirements of: U1 U2

- Sections III.G, III.J, III.L, and III.O of Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," to 10 CFR Part 50
- Appendix A to Auxiliary Power Conversion Systems Branch (APCSB) Branch Technical Position (BTP) 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to July 1, 1976."

In the FPR, TVA additionally stated that the applicable guidelines used as the basis for the plan included, in part, the following:

- NRC letter entitled, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance," dated June 20, 1977

- Generic Letter (GL) 81-12, "Fire Protection Rule (45 FR 76602, November 19, 1980)," dated February 20, 1981, and its associated clarification letter, dated March 22, 1982;

- GL 82-21, "Technical Specifications for Fire Protection Audits," dated October 6, 1982; U1 U2

- GL 83-33, "NRC Positions on Certain Requirements of Appendix R to 10 CFR 50," dated October 19 1983;

- GL 86-10, "Implementation of Fire Protection Requirements," dated April 24, 1986;

- GL 88-12,"Removal of Fire Protection Requirements from Technical Specifications," dated August 2, 1988.

The following NRC guidance was used for specific topics:

- NUREG-1852, "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire," issued October 2007, for WBN Unit 2 OMA evaluations U2

- NRC Regulatory Guide (RG) 1.189, "Fire Protection for Operating Nuclear Power Plants," Revision 0, issued April 2001, for extension of the "annual" fire protection audit interval U1 U2

- NRC RG 1.189, "Fire Protection for Nuclear Power Plants," Revision 2, issued October 2009, for OMA and multiple spurious operation (MSO) evaluations.

In Staff Requirements Memorandum SECY-07-0096, "Possible Reactivation of Construction and Licensing Activities for the Watts Bar Nuclear Plant Unit 2," dated July 25, 2007, the Commission directed the NRC staff to use the existing WBN Unit 1 licensing basis as the reference basis for the WBN Unit 2 review. To that end, where applicable, the NRC staff used the WBN Unit 1 approvals, as documented in SSER 18, issued October 1995, and SSER19, issued November 1995, to NUREG-0847, as the basis for its approvals in this evaluation, instead of the agency's current guidance. The NRC staff used the agency's current guidance as the basis for approval for the WBN Unit 2 OMAs, associated circuits, MSO, fire water system design demand, the auxiliary control room (ACR), and radiant energy shields (RES). U1 U2

The NRC staff met with TVA on January 19, February 3 and 15, March 29, April 22, May 12, June 30, July 12 and 28, August 31, November 16, and December 21, 2011, and February 2, 2012, to discuss technical issues related to WBN's fire protection program and its implementation. The NRC staff also conducted an audit at WBN from October 25-27, 2011, which it documented in a report dated December 20, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML113500239).

Unless otherwise noted, all information cited in this evaluation is from the WBN FPR dated March 13, 2013 (ADAMS Accession No. ML130840169). U1 U2

2.0 FIRE PROTECTION PROGRAM

2.1 Purpose and Scope

In FPR Part I, Section 2.0, "Purpose," TVA stated that the purpose of the FPR is to provide a detailed summary of the WBN fire protection program in a single document. The FPR is thus the "fire protection plan" document that is required by 10 CFR 50.48(a). Section 9.5.1 of the WBN Final Safety Analysis Report (FSAR) incorporates the FPR by reference. In FPR Part I, TVA states that it will be updated in conjunction with the FSAR.

The regulation at 10 CFR 50.48(a)(1) requires that licensees have a fire protection plan that satisfies General Design Criterion 3 in Appendix A to 10 CFR 50. The plan must do the following:

(i) Describe the overall fire protection program for the facility;

(ii) Identify the various positions within the licensee's organization that are responsible for the program;

(iii) State the authorities that are delegated to each of these positions to implement those responsibilities; and

(iv) Outline the plans for fire protection, fire detection and suppression capability, and limitation of fire damage.

TVA's plan provided information on Item (i) above in FPR Part II, Section 9, "Emergency Response," Section 10, "Control of Combustibles," and Section 11, "Control of Ignition Sources." TVA's plan provided information on Item (ii) above in FPR Part II, Section 7, "Fire Protection Organization/Programs," and Section 14, "Fire Protection Systems and Features Operating Requirements," and in FPR Part VI. TVA's plan provided information on Item (iii) above in FPR Part II, Section 7, "Fire Protection Organization/Programs," and in FPR Parts III, IV, V, and VI. TVA's plan provided information on Item (iv) above in FPR Part II, Section 12, "Description of Fire Protection Systems and Features." Items (i) through (iii) are evaluated in Section 2.0 of this safety evaluation. Item (iv) is evaluated in Sections 2.0 through 5.0 of this safety evaluation.

The regulation at 10 CFR 50.48(a)(2) requires that the plan must describe specific features necessary to implement the program described in 10 CFR 50.48 (a)(1), such as the following:

(i) Administrative controls and personnel requirements for fire prevention and manual fire suppression activities;

(ii) Automatic and manually operated fire detection and suppression systems; and

(iii) The means to limit fire damage to structures, systems, or components (SSCs) important to safety so that the capability to shut down the plant safely is ensured.

TVA's plan provided information on Item (i) above in FPR Part II, Section 9, "Emergency Response," Section 10, "Control of Combustibles," Section 11, "Control of Ignition Sources," and

Section 13, "Fire Protection System Impairments." TVA's plan provided information on Item (ii) above in FPR Part II, Section 12, "Description of Fire Protection Systems and Features." TVA's plan provided information on Item (iii) above in FPR Part II, Section 12, "Description of Fire Protection Systems and Features," and in FPR Parts III, IV, V, and VI. Item (i) is evaluated in Section 2.0 of this safety evaluation. Item (ii) is evaluated in Section 4.0 of this safety evaluation. Item (iii) is evaluated in Sections 3.0 and 5.0 of this safety evaluation.

The regulation at 10 CFR 50.48(a)(3) requires the licensee to retain the fire protection plan and each change to the plan as a record until the reactor license is terminated. In FPR Part I, Section 2 "Purpose," TVA stated that the FPR will be updated in conjunction with updates to the WBN FSAR. The NRC staff concludes that this an acceptable method of retaining plan records, because the FSAR is maintained and updated in accordance with 10 CFR 50.59, "Changes, Tests, and Experiments," and 10 CFR 50.71(e), respectively, which have similar retention requirements and therefore meets the requirements of 10 CFR 50.48(a)(3).

The information below describes how TVA organized its FPR.

FPR Part I is an introduction to the FPR and contains a summary table of fire protection features throughout the plant. FPR Part II of the FPR contains the overall fire protection plan. The fire protection plan describes (1) the WBN fire protection organization, (2) plant fire protection features, (3) the plant's fire prevention program, (4) the plant's emergency response organization, (5) plant operating requirements for fire protection features and systems, and (6) the testing and inspection requirements for these plant fire protection features. An overview of the post-fire safe shutdown (FSSD) is contained within FPR Part III. FPR Part IV of the FPR discusses alternate shutdown. FPR Part V describes OMAs and repairs. In FPR Part VI, the FPR summarizes the fire hazards analysis (FHA) for each fire area by describing the physical characteristics of the fire area, combustible loadings and anticipated fire severity, and fire suppression and detection capability available in each plant area. In FPR Part VI, TVA also describes how the plant would achieve post-FSSD if a serious fire occurred in the fire area. FPR Part VII documents deviations from regulatory criteria and guidance documents and presents engineering evaluations related to the adequacy of specific fire protection features. FPR Parts VIII and IX describe conformance with the guidelines in Appendix A to BTP (APCSB) 9.5-1 and in Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50, respectively. FPR Part X contains a discussion of TVA's compliance with National Fire Protection Association (NFPA) codes.

The FPR describes the measures that are established at WBN to implement a defense-in-depth fire protection program in plant areas important to safety. The objective of these measures is to: (1) prevent fires from starting; (2) detect rapidly, control, and extinguish promptly those fires that do occur; and (3) provide protection for SSCs important to safety so that a fire that is not promptly extinguished by the fire suppression activities will not prevent the safe shutdown of the plant.

2.2 Fire Protection Organization

As described in FPR Part II, Section 7, TVA's fire protection organization consists of corporate management oversight and an onsite plant implementation organization. Responsible TVA corporate managers include the Senior Vice President, the Engineering Vice President, and the Site Vice President. The onsite implementation organization includes the Plant Manager, the Operations Manager, the Operations Support Supervisor, the Fire Protection Supervisor, and the Site Engineering Manager. The NRC staff reviewed the responsibilities and authorities of each position responsible for the fire protection program, as described in FPR Part II, Sections 7.1 through 7.6, and concluded that there is reasonable assurance that the key responsibilities for implementing the fire protection program at WBN have been delegated to appropriate positions within TVA's organization, and that the authorities delegated to each position to implement these responsibilities are appropriate.

Based on its review of the FPR, the NRC staff concludes that TVA's fire protection organization does not take any exceptions to Position A.1 of Appendix A to BTP (APCSB) 9.5-1, therefore, is acceptable.

2.3 Fire Protection Quality Assurance Program

FPR Part II, Section 6.0, contains TVA's description of the quality assurance (QA) program for fire protection at WBN. TVA stated that it used the guidance established by Appendix A to BTP (APCSB) 9.5-1 and the NRC's letter dated June 20, 1977, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls, and Quality Assurance," to develop a QA program for fire protection features that protects post-FSSD capability and safety-related SSCs. The FPR states that the WBN fire protection QA program uses the applicable parts of TVA-NQA-PLN89-A, "Tennessee Valley Authority Nuclear Quality Assurance Plan."

TVA implemented a program that performs independent audits and inspections of the WBN fire protection program. TVA stated that its program is based on the guidance in GL 82-21. The FPR states that TVA's Nuclear Assurance organization is responsible for conducting the fire protection-related audits.

In TVA's letter dated May 6, 2011 (ADAMS Accession No. ML11129A158), in response to the NRC staff's request for additional information (RAI) FPR II-26, TVA stated that the frequency of the GL 82-21 annual fire protection audit has been changed to 24 months. TVA stated in its letter dated August 28, 2002, (ADAMS Accession No. ML022460173) that the plant implemented this change using a performance-based schedule. In TVA's letter dated September 30, 2011 (ADAMS Accession No. ML13060A225), in response to the NRC's question RAI FPR II-26.1, TVA stated that the change is being monitored on a fleet-wide basis, and that deficiencies found during the biennial audits would result in increasing the frequency of the audits. The NRC staff concludes that this is consistent with Position 1.7.10.1 of Revision 0 to RG 1.189, and, therefore, is acceptable.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's fire protection QA program does not take any exceptions to Position C of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

2.4 Fire Protection Administrative and Technical Controls

2.4.1 Fire Protection Program Changes, Review and Approval

TVA stated in FPR Part I, Section 2.0, that "the Fire Protection Report has been developed in accordance with the guidelines of NRC Generic Letter 86-10...and NRC Generic Letter 88-12...." TVA has elected to follow the guidance in GL 88-12 and incorporate the standard fire protection license condition as listed in GL 86-10. In addition to including, by reference, the NRC safety evaluations which approved the plant fire protection program, this license condition allows TVA to make changes to the approved program without prior approval of the NRC if those changes would not adversely affect the plant's ability to achieve and maintain safe shutdown in the event of a fire.

Based on its review of the information submitted by TVA, the NRC staff concludes that no exceptions were taken to the positions in GL 88-12, and it is therefore, acceptable.

2.4.2 Fire Protection Administrative Controls

2.4.2.1 Control of Combustibles

FPR Part II, Section 10.0, describes TVA's program to control combustibles. The WBN combustible control program objectives are to (1) provide instruction and guidelines during general employee training on the application and use of combustible materials at WBN, (2) control the application and use of chemicals, (3) perform periodic plant housekeeping inspections and have housekeeping tours by management and the onsite fire protection organization, (4) control in situ combustibles through the design/modification review and installation process, and (5) control transient combustibles through the implementation of administrative controls.

TVA stated that it has established a plantwide administrative procedure to control transient combustibles. Implementation of this procedure will establish administrative controls for the handling of combustible materials such as fire-retardant wood, paper, plastic, and flammable and combustible gases and liquids. In addition, through its combustible control program, TVA has established combustible control zones in the plant. TVA considers these zones to be subdivisions of fire areas and to limit fire spread by providing open space free of transient combustibles between redundant FSSD equipment or cables. Transient combustibles may not be stored in these zones unless an adequate fire protection engineering evaluation or compensatory measures, or both, are implemented.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's program to control combustibles does not take any exceptions to Positions B.2 and B.3.c of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

2.4.2.2 Control of Ignition Sources

TVA has established a program for controlling ignition sources such as welding, cutting, grinding, and the use of open flame. TVA's program specifies that the issuance of "hot work" permits be reviewed and approved based on plant conditions and a prior inspection of the proposed work area. The ignition source on a hot work permit is valid for only one job. Before the start of work, the work area is made "fire safe." In addition, TVA's program will establish a hot work fire watch for all ignition source work activities that are performed in safety-related and safe-shutdown areas of the plant. These fire watches, in addition to performing their duties during the hot work activities, will remain in the area for a minimum of 30 minutes after the work has been completed to ensure that potential residual ignition conditions do not exist.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's program to control ignition sources does not take any exceptions to Positions B.3.a and B.3.b of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

2.4.3 Compensatory Measures

Compensatory measures described in FPR Part II are used to compensate for degraded or nonfunctional fire protection systems or features. Primarily, these compensatory measures take the form of both roving and continuous fire watches.

FPR Part II, Section 13.B states, "A roving fire watch consists of a trained individual in an affected location at 60 minute intervals with a 15 minute margin to accommodate and handle unforeseen circumstances and to report and/or resolve potential fire hazards in a location. Roving fire watches are required as a compensatory action in all modes of plant operation (i.e., Modes 1 through 6 or core empty)." The NRC staff concludes that this takes no exceptions to Positions B.3 and B.5.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

As described in FPR Part II, Section 13.A, a continuous fire watch possesses the following attributes: (1) the trained person performing the fire watch must be in the fire area at all times; (2) the fire area must not contain any impediment to restrict the movements of the fire watch; and (3) each compartment within the fire area must be patrolled at least once every 15 minutes with a margin of 5 minutes. The NRC staff concludes that this takes no exceptions to Positions B.3 and B.5.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

In the FPR, TVA identified specific exceptions to the above requirements for roving and continuous fire watches. In FPR Section 13.0, TVA identified continuous fire watch routes in more than one fire area that it classifies as exceptions to a continuous fire watch remaining within one fire area. As a basis for acceptability, TVA identified the following characteristics: (1) one or more rooms in different fire areas whose proximity to one another and their limited size warrant the combining of them into one continuous fire watch route, (2) a time study that confirms the route can be covered in 15 minutes without putting undue exertion on the person performing the fire watch, and (3) in each instance, these routes require the Fire Protection Supervisor's approval to ensure that the conditions that formed a basis for the time study have not changed in such a manner as to invalidate the time study. In the event that the automatic suppression or detection systems in the above areas cannot be restored within the time specified by FPR Part II, Section 14.0, TVA stated that the continuous fire watch patrols would not be allowed to include more than one fire area. Based on the submitted information, the NRC staff concludes that this takes no exceptions to Positions B.3 and B.5.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

The WBN FPR states that continuous fire watches are only required when the affected unit is in Mode 1 (power operation) through Mode 4 (hot shutdown). In FPR Part II, TVA stated that, when one unit is in Modes 5, 6, or core empty, locations where a continuous fire watch would be required may be combined and patrolled by a roving fire watch when approved by the Fire Protection Supervisor, if a fire in those locations could not affect the other unit, if it is in Modes 1 through 4. Based on the submitted information, the NRC staff concludes that this takes no exceptions to Positions B.3 and B.5.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

In addition, in the FPR Part II, Section 13.0, TVA identified other alternative compensatory measures that may be used at WBN in lieu of the above standard compensatory measures. In all cases, in which an alternative compensatory measure is used for a degraded or nonfunctional fire protection feature, TVA stated that it will perform an evaluation that demonstrates technical equivalency to the standard compensatory measure identified in FPR Part II, Section 14.0. TVA described the following alternatives that may be considered when supported by an appropriate technical evaluation: (1) providing additional or alternative fire protection equipment, (2) installing temporary or portable fire detection systems in conjunction with an hourly roving fire watch, (3) installing closed circuit television cameras and monitors in areas when special circumstances, such as personal safety or as-low-as reasonably-achievable (ALARA; radiological) concerns, preclude the use of a human fire watch in the area, and (4) taking credit in continuously manned areas for the constant manning in lieu of establishing either continuous or roving compensatory fire watches when the responsible individuals accept this responsibility. Based on its review of the information submitted by TVA, the NRC staff concludes that these alternatives take no exceptions to Positions B.3 and B.5.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

2.4.4 Fire Protection Technical Controls

In FPR Part II, Section 14, TVA established operability requirements for the following fire protection features: (1) fire detection instrumentation, (2) water supply, (3) water-based fire suppression systems, (4) carbon dioxide (CO2) suppression systems, (4) fire detection supervisory equipment, (6) fire hose stations and associated pre-action control valves, (7) fire hydrants, (8) fire-rated assemblies, and (9) emergency battery lighting units.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's operability requirement program for plant fire protection features does not take any exceptions to Positions B.1, B.3, and B.5 of Appendix A to BTP (APCSB) 9.5-1, and, therefore, is acceptable.

GL 88-12 provides guidance for removing fire protection limiting conditions for operation and surveillance requirements associated with fire detection systems, fire suppression systems, fire barriers, and administrative controls that address fire brigade NRC staffing from the plant's technical specifications (TSs) and incorporating this information into the FSAR. In addition, GL 88-12 refers to GL 81-12, which requested licensees to provide TSs for equipment used for safe shutdown capability that is not currently covered by existing TSs. In its fire protection plan, TVA confirmed that the plant equipment used to achieve and maintain post-FSSD from either inside or outside the main control room (MCR) is included in either the plant TSs or the FPR.

Table 14.10,"Fire Safe Shutdown Equipment," of FPR Part II, Section 14, lists the FSSD equipment not included in the plant's TSs. TVA established testing and inspection requirements which assist in evaluating the operability of the non-TS-related FSSD equipment and instrumentation. In FPR Part II, Section 14.0, TVA established the requirements with this equipment or instrumentation inoperable. TVA requires, with one or more of the required items of equipment listed in Table 14.10 inoperable (or a breaker or valve not in its safe shutdown position), that the plant restore the equipment to the operable status within 30 days, or that it either: (1) place the equipment in the condition required for FSSD, (2) provide a backup means of instrumentation monitoring, (3) provide an alternative means of achieving post-FSSD (along with an evaluation justifying the alternative), or (4) be in Mode 3 within 6 hours and Mode 4 within the following 12 hours.

Based on the information provided in FPR Part II, the NRC staff concludes that TVA's removal of fire protection features from the plant's TSs and relocation to the FPR as operating requirements is consistent with the guidance in GL 88-12 and GL 81-12, and, therefore, is acceptable.

In addition, in FPR Part II, Section 14, TVA established testing and inspection requirements for the following fire protection features: (1) fire detection instrumentation, (2) water supply, (3) water-based fire suppression systems, (4) CO2 suppression systems, (5) fire detection supervisory equipment, (6) fire hose stations and associated pre-action control valves, (7) fire hydrants, (8) fire-rated assemblies, (9) emergency battery lighting units, and (10) the FSSD equipment identified in Table 14.10.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's surveillance and test program for plant fire protection features does not take any exceptions to Position B.5 of Appendix A to BTP (APCSB) 9.5-1, and, therefore, is acceptable.

2.5 Fire Brigade and Fire Response

2.5.1 Organization

FPR Part II, Section 9.1, "Fire Brigade NRC Staffing," states that a fire brigade comprising of at least five members will be maintained on site at all times. In the FPR, TVA stated that these five members will consist of the fire brigade leader and four fire brigade members. In addition, neither the shift operations supervisor nor the other members of the operations shift crew needed to perform a safe shutdown of the WBN units will be included in the fire brigade. In addition, the fire brigade will not include any other individuals required for other essential plant functions that may be necessary during a fire emergency.

TVA also stated that an incident commander is available to direct each shift fire brigade in addition to the five-member fire brigade. The incident commander has sufficient knowledge of plant safety systems to understand the effects of fire and fire suppression on safe shutdown capability.

TVA stated that before initial training and annually thereafter its fire brigade program requires each fire brigade member to undergo a medical review and to receive medical approval to perform strenuous physical activities related to fire fighting and to wear special respiratory equipment.

TVA stated that the fire brigade may comprise of less than five members for a period of time not to exceed 2 hours, to accommodate for unexpected conditions such as an unplanned absence, or brigade response to a non-fire emergency.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's fire brigade NRC staffing and organization does not take any exceptions to Positions B.4 or B.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

2.5.2 Training

FPR Part II, Section 9.3 "Training and Qualifications," states that TVA's fire brigade training program consists of initial training, recurrent training, and annual fire brigade training.

The initial training program includes: (1) instruction and practical exercises in fire extinguishment and the use of fire-fighting equipment, (2) identification of fire hazards and types of fires that could occur in the plant, (3) identification of the location of fire-fighting equipment in each fire area of the plant, (4) instruction on the proper use of plant fire-fighting equipment, (5) instruction on the proper use of communications, lighting, ventilation, and emergency breathing apparatus, (6) instruction on the toxic characteristics of the products of combustion, and (7) instruction and practical exercises in fighting fires inside buildings and tunnels. In addition to initial training, the program instructs the fire brigade is instructed on fire-fighting procedures and procedure changes, the plant fire-fighting plan, with emphasis on each individual's responsibility, and the latest plant modifications and changes affecting the fire-fighting plans.

The recurrent training consists of classroom instruction meetings held every 3 months. These meetings repeat the initial training subjects over a 2 year period. Each member of the fire brigade is required to attend this training in order to remain qualified. TVA preplans fire brigade drills to establish the objectives, and the fire brigade training instructor or the instructor's designee conducts these drills. The conduct of onsite fire brigade drills are conducted as follows: (1) a minimum of one drill per fire brigade shift will be conducted every 92 days, (2) a minimum of one unannounced drill will be conducted per fire brigade shift per year, and (3) at least one drill per fire brigade shift will be conducted on the backshift. Each fire brigade member is required to attend at least two drills per year.

TVA holds annual training for each fire brigade member. TVA stated that this training provides instruction, under actual fire-fighting conditions, on the proper methods for fighting various types of fires similar in magnitude, complexity, and difficulty to those that could be encountered in the plant. This training includes actual fire extinguishment and the use of fire-fighting equipment under strenuous conditions. TVA stated that if a brigade member misses or does not complete a training session, either annual or quarterly; the member is placed in an ineligible status until the training is completed.

In addition to the annual fire brigade training, TVA holds annual briefings for the local fire departments to ensure their continued understanding of their role in the event of a fire emergency at the site. TVA also holds an annual drill for the local fire department and the plant fire brigade. The local fire department briefings and drills are held for those departments that have active aid agreements with the plant.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's fire brigade training program does not take any exceptions to Positions B.5.b and B.5.c of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

2.5.3 Equipment

In the FPR, TVA stated that fire-fighting equipment is provided throughout the plant and is strategically placed near the fire hazards present or anticipated. TVA stated that delays in the fire brigade obtaining fire-fighting equipment are minimized because of the distribution and availability of this equipment throughout the plant. TVA further stated that firefighting equipment may be staged adjacent to, or at the access to, areas/locations to facilitate equipment availability or to address equipment surveillance test concerns relative to life safety and ALARA practices.

The equipment available to the fire brigade includes: (1) motorized fire-fighting apparatus, (2) portable ventilation equipment, (3) fire extinguishers, (4) self-contained breathing apparatus, (5) fire hose, nozzles, and fittings, (6) foam equipment, (7) personal protective equipment, (8) communications equipment, (9) portable lighting, and (10) ladders specifically dedicated for fire-fighting.

Based on its review of the information submitted by TVA, the NRC staff concludes that no exceptions were taken to Position B.5.d of Appendix A to BTP (APCSB) 9.5-1 and therefore, TVA's fire brigade is acceptably equipped.

2.5.4 Fire Emergency Procedures and Pre-Fire Plans

As described in the FPR, TVA's fire emergency procedures and pre-fire plans specify the actions that the individual who discovers a fire must take and the actions that the emergency response organization must consider (e.g., control room operators and the plant fire brigade). These procedures provide different levels of response based on whether actual fire/smoke conditions are reported or whether a fire detection system annunciation occurs. (For example, a single fire detection system zone annunciation in a cross-zoned area will not carry the same level of response as a cross-zone annunciation in the same area).

TVA stated that it has implemented pre-fire plans to provide guidance, depending on the particular circumstances, to aid in firefighting efforts. TVA has developed pre-fire plans to support the fire-fighting activities in plant areas important to safety. Specifically, these plans are developed for safety-related areas, FSSD areas, and areas that present a hazard to safety-related equipment or plant shutdown.

The pre-fire plans provide the following information to the fire brigade: (1) plant equipment in the fire area, (2) access and egress routes to the fire area, (3) fire-fighting strategy and tactics, (4) locations of fire protection features and equipment, (5) special fire, toxic, and radiological hazards in the area, (6) special precautions, and (7) ventilation methodology. Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's proposed fire brigade preplans and fire emergency procedures do not take any exceptions to either the NRC letter dated June 20, 1977, or 10 CFR 50.48(a)(2) and, therefore, are acceptable.

3.0 GENERAL PLANT FIRE PROTECTION AND SAFE SHUTDOWN FEATURES

3.1 Fire Protection Design

3.1.1 Building and Compartment Fire Barriers

TVA stated that the fire rated assemblies at WBN are part of the passive fire protection features that ensure that one set of redundant FSSD components necessary to achieve and maintain FSSD remains free of fire damage. At WBN, fire-rated assemblies consist of fire barriers, raceway protection, fire doors, fire dampers, and penetration seals.

At WBN, fire areas are defined by rated wall and floor/ceiling assemblies. TVA stated that fire areas are separated by wall and floor/ceiling assemblies that are 2-or 3-hour equivalent fire barriers that are bounded by Underwriters Laboratories (UL), Inc., rated designs. In FPR Part II, Sections 12.10 and 12.10.1, TVA states that the walls that separate buildings and walls between rooms that contain safe shutdown systems are fire-rated assemblies. Rooms within each fire area may be separated from other rooms in the same fire area by regulatory or non-regulatory fire barriers. Where barriers are needed between rooms, TVA stated that only fire rated barriers with a minimum 2-hour rating are relied upon, except for portions of the MCR complex that have 1-hour rated barriers. Sections 6.2.3, 6.2.5, 6.2.6, and 6.2.7 of this evaluation provide NRC staff evaluations of deviations to fire barrier ratings.

In general, the fire barriers comprising compartment walls and floors/ceilings at WBN are constructed of reinforced concrete or concrete block. The reinforced concrete fire barriers and concrete block barriers are at least 8 inches thick. TVA's evaluation of reinforced concrete barriers used information from Section 6, Chapter 5 of the NFPA Fire Protection Handbook, 17th Edition (hearafter referred to as the Handbook). This section of the Handbook correlates fire rating and thickness of reinforced concrete. On this basis, Figure 6-5G in the Handbook shows that 6 inches of reinforced concrete has a fire resistance of approximately 4 hours. The concrete block barriers are only used when barriers are required to have a fire rating of 2-hours or less. TVA's evaluation of these fire barrier designs concludes these are similar to UL listed concrete block barrier designs (Designs Nos. U904, U905, U906, and U907) which are 2-to 4-hour fire-rated.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, TVA's proposed technical basis for the fire resistive capability of fire area boundaries offers an equivalent level of fire safety to that of Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

3.1.2 Fire Barriers Used To Separate Redundant Safe Shutdown Functions within the Same Fire Area

Cable raceways that require separation due to redundant trains located in the same fire area, excluding primary containment and secondary containment (the annulus), are separated by either 1-or 3-hour fire rated barrier systems. TVA uses a 1-hour fire rated barrier system if automatic detection and automatic suppression are installed in the areas and uses a 3-hour fire rated barrier system if automatic suppression is not installed in the area. Cable raceways that require separation due to redundant trains inside the reactor building, which includes primary containment (WBN Unit 1 only) and secondary containment (i.e., the annulus) (both units), rely on RESs or automatic detection and suppression to provide separation. RESs are addressed in Section 6.1.2 of this evaluation. U1 U2 U1

In FPR Part II, Section 12.10.2, TVA stated that the 1-and 3-hour fire rated barriers were tested in accordance with the guidance in Supplement 1,"Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains within the Same Fire Area," to GL 86-10. This guidance includes test parameters, thermocouple placement, conduit and cable tray configurations, hose stream tests, and ampacity derating. TVA also evaluated fire barriers for seismic considerations. Configurations of raceway fire barriers that are not consistent with the testing have been evaluated to ensure that untested configurations are bounded by tested configurations. TVA has procedural controls for evaluating field changes to designed configurations. TVA stated that personnel who perform such field changes are to be cognizant of the important parameters.

U1
U2

Based on its review of the submitted information, the NRC staff concludes that TVA's use of the guidance in Supplement 1 to GL 86-10, with the consideration of seismic events, bounding of untested configurations, and procedures to control field changes, offers an equivalent level of fire safety to that of Position D.3 of Appendix A to BTP APCSB 9.5-1 and, therefore, is acceptable.

3.1.3 Equipment Hatches and Stairwells

TVA stated that at WBN equipment hatches in the floor or fire barriers in the ceiling can be categorized as follows:

- precast concrete plugs
- steel covers
- open hatches and stairwells

TVA stated that the precast concrete plugs are associated with radiation shielding and, as fire barriers, are equivalent to the floor or ceiling fire barrier in which they are located. TVA stated that the steel covers are of substantial construction and that they provide an effective barrier to prevent fire from propagating from one side of the barrier to the other. In addition, because the covers are not fire rated, they are either provided with a draft stop and water curtain around them or redundant safe shutdown components on either side have been separated from each other by a cumulative horizontal distance of 20 feet or more. In either case, automatic fire suppression and detection are provided on both sides of the equipment hatch cover.

FPR Part VII, Section 2.6.4, summarizes TVA's evaluation for the deviation of the non-rated equipment hatches separating the control building and turbine building. Section 6.2.7.4 of this evaluation provides the NRC staff evaluation of this deviation.

TVA stated that, in areas in which open hatches and stairwells are located, redundant shutdown trains are either separated by at least 20 feet horizontally, one train has been protected by a 1-hour fire barrier, or a water curtain has been installed around the opening. In any case, fire detection and automatic suppression systems are located on both sides of the openings. Further, TVA stated that the only exception to this arrangement is in the refueling area of the auxiliary building.

FPR Part VII, Section 2.6.3, summarizes TVA's evaluation of the deviation for non-rated open hatches and stairwells that do not fully meet the NRC staff guidance. Section 6.2.7.3 of this evaluation provides the NRC staff evaluation of this deviation.

FPR Part VII, Section 4.5, summarizes TVA's evaluation of the lack of fire detection in the refueling area. Section 6.2.1 of this evaluation provides the NRC staff evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, TVA's design criteria and bases related to the equipment hatches and stairwells are in accordance with the guidelines of Positions D.1.j and D.4.f of Appendix A to BTP APCSB 9.5-1 and, therefore, are acceptable.

3.1.4 Fire Doors

In FPR Part II, Section 12.10.4, TVA stated that fire door assemblies (doors, frames, and hardware) are provided for door openings required as part of fire barriers. Fire doors have been evaluated in accordance with NFPA 80-1975, "Standard for Fire Doors and Fire Windows." Fire doors are normally provided with closing mechanisms. In addition, TVA stated in FPR Part VII, Section 4.1, that some fire doors have been altered by the addition of signs and security hardware, or have been damaged and repaired onsite. Closing mechanisms and latches provided on doors are inspected to ensure proper functioning. Special purpose doors (e.g., flood, heavy equipment) installed in fire barriers have been evaluated by a fire protection engineer for acceptability.

TVA installed UL listed fire door assemblies (doors, frames, and hardware) in door openings that are required as part of fire barriers. These door assemblies are either A-labeled (3-hour), for 3-hour fire barriers or B-labeled (1½-hour), for fire barriers having a fire rating of 2 hours or less. Furthermore, TVA stated that security hardware incorporated into a fire door assembly does not adversely impact the fire rating of the assembly in accordance with NRC staff guidance in Section 3.2.3 of GL 86-10. Sliding fire doors are provided in selected locations, such as rooms protected with gaseous fire suppression systems. These sliding fire doors are closed by a fusible link or CO2 system actuation, or both.

TVA stated that in areas protected by automatic CO2 suppression systems, fire doors close upon the CO2 system actuation. The thermal link on the fire doors actuates and closes prior to CO2 fire suppression system discharge.

TVA stated that special purpose doors (e.g., air lock doors, equipment doors, and submarine-type doors) cannot be purchased as labeled fire-rated doors. FPR Part VII, Section 4.1, summarizes TVA's evaluation for the deviation of these types of fire door from the NRC staff guidance. Section 6.2.2 of this evaluation provides the NRC staff evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, TVA's design criteria and bases related to the installation of fire doors in fire barrier assemblies are in accordance with the guidelines of Position D.1.j, of Appendix A to BTP APCSB 9.5-1 relating to the fire doors and, therefore, are acceptable.

3.1.5 Fire Dampers

Fire dampers are used to maintain the required ratings of fire-rated barriers (walls, partitions, and floors) when they are penetrated by ductwork, with the goal of preventing the propagation of fire through ducts. TVA stated that fire dampers are provided in heating, ventilation, and air conditioning (HVAC) ducts that penetrate required fire barriers. Some duct penetrations do not have fire-rated dampers and are unprotected openings. Fire dampers are provided with appropriately rated fusible links based on the ambient temperatures in the location. Fire dampers in safety-related HVAC systems may have double fusible links installed if required by a single failure analysis. Furthermore, TVA stated that ventilation openings through fire barriers required to comply with NRC regulations are protected by fire dampers having a rating equivalent to that required of the barrier. TVA stated that fire dampers have been evaluated per the requirements of NFPA 90A-1975, "Standard for the Installation of Air Conditioning and Ventilating Systems."

In areas protected by automatic CO2 suppression systems, these dampers also close during the CO2 system discharge. The fire dampers that provide CO2 suppression system isolation capability are actuated by a release mechanism when the CO2 system activates, if not actuated by a thermal link prior to CO2 system discharge.

In FPR Part VII, Section 3.4, TVA stated that there are two instances of large fire dampers that do not meet NRC staff guidance. Section 6.2.8 of this evaluation provides the NRC staff evaluation of this deviation.

FPR Part VII, Section 3.5, summerizes TVA's evaluation for the deviation of the fire damper in the volume control tank (VCT) rooms' fire door from the NRC staff guidance. Section 6.2.10 of this evaluation provides the NRC staff evaluation of this deviation.

FPR Part VII, Section 6.2, summerizes TVA's evaluation of relaxing the surveillance frequencies for fire dampers in high radiation or contaminated areas. Section 6.3.2 of this evaluation provides the NRC staff evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, fire dampers at WBN are installed consistent with Positions D.1.j and D.4.i of Appendix A to BTP APCSB 9.5-1, and, therefore, are acceptable.

3.1.6 Fire Barrier Penetration Seals

3.1.6.1 Electrical and Mechanical Penetration Seals

In FPR Part II, Section 12.10.6, TVA discussed seals that are installed in areas in which plant commodities, such as pipes, cable trays, conduits, etc., pass through fire rated barriers. TVA tested these seals to the time-temperature curve in American Society for Testing and Materials (ASTM) standard ASTM E119, "Standard Test Methods for Fire Tests of Building Construction and Materials," at an independent fire testing laboratory with experience in the testing of penetration seals.

The testing showed that the penetration seals could withstand the fire endurance test without the passage of flame or gases hot enough to ignite cable or fire stop material on the unexposed side for a period equal to the required fire rating. In addition, for seals required to meet other plant design bases requirements, such as radiation shielding, HVAC pressure differential, and/or flood, they were tested for such capability.

TVA stated that the penetration seal configurations at WBN have withstood a hose stream test in accordance with Institute of Electrical and Electronics Engineers (IEEE) 634-1978, "Cable-Penetration Fire Stop Qualification Test," or ASTM E-814-83, "Standard Test Method for Fire Tests of Penetration Firestop Systems," without the hose stream causing an opening through the penetration seal that would permit a projection of water beyond the unexposed side.

TVA stated that the 1-, 2-, and 3-hour fire rated mechanical penetrations were tested in accordance with ASTM E-814-83, for the fire and "T" rating. The "T" rating acceptance criteria is limited to a temperature rise of 325 degrees Fahrenhiet (F) above ambient for cold side penetration seal surface temperatures. Service temperature and any thermal or mechanical movement of the pipe were also considered in the testing of the mechanical penetration seals.

TVA stated that 1-, 2-, or 3-hour fire rated electrical penetration seals were tested in accordance with IEEE 634-1978. Transmission of heat through the penetration seal was limited to 700 degrees F or the lowest auto-ignition temperature of cable in the penetration, whichever is lower.

Conduit penetrations that were poured in place during plant construction have internal seals. TVA stated that internal seal materials, design, and locations in walls and floor/ceiling assemblies have been evaluated as equivalent to tested configurations. For conduits with external seals (e.g., the conduits passing through a sleeve larger than the conduit), the external seal meets the same criteria as stated for electrical penetration seals.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection information presented in the FPR conforms to the guidelines of Positions D.1.j and D.3.d of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

3.1.6.2 Internal Conduit Fire Barrier Penetration Seals

TVA stated that conduits that pass through fire barriers are provided with internal smoke and gas seals. TVA stated that these seals have a minimum of 3 inches of silicone foam and 1 inch of ceramic fiber damming installed at the bottom or back side of the foam seal. TVA further stated that conduits that terminate in closed junction boxes or other noncombustible sealed enclosures do not need internal smoke seals, except for conduits in the auxiliary and secondary containment envelope boundary. In addition, that an electrical cubicle, such as in a motor control center (MCC) or in a switchgear cabinet, is considered combustible and therefore would have internal conduit seals at or near the fire barrier. Conduits that are routed through the fire area and that do not terminate in the area do not have internal seals.

For lengths of conduit that extend less than 1 foot beyond the plane of a fire barrier, regardless of diameter, a fire seal is installed. For other combinations of diameters and lengths of conduit, TVA uses a graded approach for the installation of internal conduit seals, as provided in FPR Part II, Section 12.10.6. For smaller diameter conduits, a short length of conduit from the barrier is sufficient to restrict smoke or hot gases. For larger diameter conduits, longer lengths of conduit from the barriers are needed to adequately restrict the travel of smoke or hot gases.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's criteria for the installation of internal conduit fire and smoke seals are equivalent to the guidelines of Positions D.1.j and D.3.d of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

3.2 Safe Shutdown Capability

3.2.1 Separation of Safe Shutdown Functions

In order to ensure that one train of equipment remains free of fire damage, where components of redundant trains of systems necessary to achieve and maintain hot shutdown conditions are located within the same fire area outside the containment, TVA stated that equipment, components, cables, and associated circuits of redundant, safe shutdown systems are separated in accordance with the following separation criteria in Section III.G.2(a) through Section III.G.2(c) of Appendix R to 10 CFR 50:

(a) Separation of cables and equipment and associated non-safety circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that required of the barrier;

(b) Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; or

(c) Enclosure of cable and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area;

For safe shutdown components located inside the containment building, TVA used one of the means noted above, or one of the following means to achieve separation between trains:

- fire detectors and automatic fire suppression installed in the area; or
- separation of equipment, components, and associated circuits of redundant systems by a RES

In order to conform to the fire protection and safe shutdown train separation criteria as described in Section III.G.2(b) of Appendix R to 10 CFR Part 50 listed above, TVA took credit for a safe shutdown analysis volume (AV) evaluation methodology and also took credit for enhanced automatic fire suppression consisting of pre-action sprinklers located at the ceiling level and below obstructions in the large general plant areas, and area-wide ionization smoke detection.

TVA used the AV methodology in order to sub-divide a large fire area and then subject it to a detailed safe shutdown analysis in accordance with Appendix R to 10 CFR Part 50 and ensure that one train of safe shutdown capability remains free of fire damage.

Under TVA's analysis volume methodology, an AV can consist of an entire fire area or a portion of a larger fire area. When the AV is a portion of the fire area, it can consist of multiple rooms, a single room, portions of a room (normally defined by column line locations), or any combination of the above. Each AV that involves only a portion of a room includes a 20 foot wide (minimum) "buffer zone" between it and the adjacent AV. The buffer zones are analyzed as part of the larger AV and as a separate AV. Every portion of a fire area is part of at least one AV.

In performing the safe shutdown analyses, safe shutdown components and cables are assigned to each AV containing the component. Additionally, components located in the buffer zones are assigned to an AV for the buffer zone.

TVA's safe shutdown analysis is performed assuming that all components and cables in the AV are damaged by the postulated fire. A set of safe shutdown equipment is then selected and corrective actions designated to ensure safe shutdown functions can be maintained with the selected equipment.

Some AVs in the plant use electrical raceway fire barrier system (ERFBS) for redundant trains located within a single AV. The ERFBS extends to the boundary of the AV to assure separation between redundant trains within the AV. For large AVs, this may not be a barrier; rather it may be the column line or other indicator of the edge of the AV.

In order to provide reasonable assurance that WBN satisfied the technical requirements in Section III.G, "Fire Protection of Safe Shutdown Capability," of Appendix R to 10 CFR Part 50, TVA identified and used the following types of analysis volumes, as described with figures in FPR Part III, Section 10.3:

- Fire Area -The fire area is separated from other adjacent areas by rated barriers (walls, floors, and ceilings) that are sufficient to withstand the hazards associated with the area and, as necessary, to protect equipment in the area from a fire outside the area.

- Single Room within a Fire Area -A room may be separated from other adjacent rooms in a fire area by regulatory fire barriers (walls, floors, and ceilings) that have a 1-hour or greater fire rating.

- Combination of Rooms within a Fire Area -The combination of rooms in the AV are separated from other AVs within the same fire area by regulatory fire barriers that are rated for at least 1-hour

- Sections of Large General Areas -AVs consisting of sections of large general areas are separated from each other by "buffer zones" that are wider than 20 feet. In large general areas where buffer zones are used that include intervening combustibles, enhanced automatic suppression and detection systems are installed in the large general area. Where AVs are separated from other AVs by buffer zones, a fire in one of the AVs would not be expected to pass through the buffer zone and affect equipment in the AV on the other side of the buffer zone. TVA uses combinations of overlapping AVs in their analysis.

- Sections of Large Rooms -For AVs that consist of large room sections separated by an overlap region that is greater than 20 feet, the overlap region is considered to be part of both AVs. If the overlap region contains intervening combustibles, enhanced automatic suppression and detection systems are installed in the large room.

For large general areas and large rooms that have either buffer zones or overlap regions, refer to Section 6.1.4 of this evaluation for additional information regarding fire protection in those regions.

Based on its review of the submitted information, the NRC staff concludes that TVA's criteria for providing fire protection for safe shutdown functions provides an equivalent level of fire safety to Section III.G. of Appendix R to 10 CFR Part 50 and is, therefore, acceptable.

3.2.2 Safe Shutdown -General Plant Areas

TVA's methodology for assessing compliance with the separation/protection requirements of Section III.G of Appendix R to 10 CFR Part 50 consisted of:

(a) Determining the functions required to achieve and maintain safe shutdown

(b) Producing shutdown logic diagrams that define minimum sets of systems capable of accomplishing each shutdown function

Each plant system or subsystem function relied on to accomplish the above safe shutdown functions is identified. A separate designator is assigned to each plant system or subsystem function to ensure consistency between analysis documents and calculations. Each designator is identified as a safe shutdown "Key." The safe shutdown logic diagram (FPR Figure III-5) depicts the safe shutdown system and/or system function, associated Key number, and logical relationships between systems and Keys used to demonstrate compliance with the criteria in Appendix R to 10 CFR Part 50.

(c) Grouping specific plant locations into fire areas

(d) Identifying for each area, one or more paths through the shutdown logic diagrams that satisfy each required shutdown function

(e) Developing functional criteria that defined the required equipment for the shutdown paths

(f) Identifying power and control cables for shutdown-related equipment and associated circuits that are not isolated from shutdown cabling

For each safe shutdown key, cable block diagrams were developed for each safe shutdown component to identify cables required to ensure that the component can perform its safe shutdown function. Raceways that contain these required cables were then identified, and their locations documented. An interaction is defined as a place in the plant where redundant safe shutdown paths are not separated in accordance with the requirements in Section III.G.2 of Appendix R to 10 CFR Part 50. Whenever an interaction was identified, it was documented and evaluated for its impact on safe shutdown capability. An appropriate resolution was then determined and documented.

(g) Resolutions may consist of modifications, use of alternate equipment, OMAs, fire barrier or radiant energy shield installation, post-fire repairs, engineering evaluations prepared in accordance with the guidance in GL 86-10, or deviation requests

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's methodology for assessing compliance with the separation/protection requirements in Section III.G of Appendix R to 10 CFR Part 50, is acceptable.

3.2.3 Safe Shutdown Analysis

TVA stated that its safe shutdown analysis demonstrated that sufficient redundancy exists for systems needed for hot and cold shutdown. The safe shutdown analysis included components, cabling, and support equipment needed to achieve hot and cold shutdown.

TVA stated that for hot shutdown, at least one train of the following safe shutdown systems would be available: (1) auxiliary feedwater (AFW) system, (2) steam generator (SG) power-operated relief valves (PORVs), (3) reactor coolant system (RCS), and (4) chemical and volume control system. For cold shutdown, at least one train of the residual heat removal (RHR) system would be available. TVA stated that the RHR system provides the capability to achieve cold shutdown within 72 hours after a fire, and would be used for long-term decay heat removal. The availability of these systems includes the components, cabling, and support equipment necessary to achieve cold shutdown. Support equipment includes the diesel generators and associated electrical distribution system, the essential raw cooling water (ERCW) system, the component cooling water system (CCS), and the necessary ventilation systems.

TVA stated that an electrical separation study was performed to ensure that at least one train of such equipment is available in the event of a fire in areas that might affect these components. Safe shutdown equipment and cabling were identified and traced through each fire area from the component to the power source. Associated circuits whose fire-induced spurious operation could affect safe shutdown were identified by a system review to determine those components whose maloperation could affect safe shutdown capability. The potential for MSO was also analyzed. Further discussion of the MSO is presented below in Section 3.9, "Assessment of Multiple Spurious Operations."

TVA stated that alternative shutdown measures are required only for fires in the control building. If a fire disables the MCR or requires the evacuation of the MCR, the ACR, which is located in a separate fire area in the auxiliary building, would be available to achieve and maintain the plant in hot standby and subsequent cold-shutdown conditions. The control functions and indications provided at the ACR panel are electrically isolated or otherwise separate and independent from the MCR. Further discussion of the alternative shutdown capability is presented below in Section 3.3, "Alternative Shutdown."

Based on its review of the information submitted by TVA, the NRC staff concludes that the systems identified by TVA for achieving and maintaining safe shutdown in the event of a fire as described in Section III.G of Appendix R to 10 CFR Part 50 are acceptable.

3.2.4 Systems Required for Safe Shutdown

TVA stated that shutdown of the reactor and reactivity control is initially performed by control rod insertion. Long term reactivity control is provided by adding borated water from the refueling water storage tank (RWST). RCS inventory is maintained by varying charging and letdown flow through the RCS makeup and letdown paths. Decay heat removal during hot shutdown is accomplished by establishing secondary-side pressure control and supplying water to two of the four SGs from one of the redundant motor-or turbine-driven AFW pumps. Long-term heat removal to establish and maintain cold-shutdown conditions is provided by the RHR system.

TVA stated that primary system pressure is controlled by the pressurizer heaters (if available) or by varying pressurizer level in combination with control of SG pressure and RCS temperature using SG PORVs.

Based on its review of the information submitted by TVA, the NRC staff concludes that the systems selected by TVA are capable of satisfying the post-FSSD requirements in Sections III.G and III.L of Appendix R to 10 CFR Part 50, and therefore, are acceptable.

3.3 Alternative Shutdown

3.3.1 Areas in Which Alternative Shutdown Is Required

TVA's analysis identified that alternative shutdown capability is required for control building fires that also require shutdown from outside of the MCR. For these fires, cold shutdown must be achieved within 72 hours. TVA also indicated that it evaluates the alternative shutdown capability in accordance with Sections III.G.3 and III.L of Appendix R.

3.3.2 Alternative Shutdown System

The alternative shutdown system uses existing plant systems and equipment identified in Section 3.2 above, and an ACR complex. TVA stated that the analysis indicates that for control building fires, no repairs are required to implement the alternative shutdown capability.

A loss of offsite power is required to be postulated for those locations that require alternative shutdown. TVA stated that the systems used during alternative shutdown are can be powered by both onsite and offsite power.

The ACR complex is physically independent of the control building. Where required, electrical isolation of controls and indications provided for the ACR is achieved through the actuation of isolation/transfer switches. The ACR complex is divided into five independent rooms consisting of a Train A and Train B transfer switch room for each unit and the ACR. The ACR serves as the central control point during alternative shutdown from outside the MCR, and provides control and monitoring capability for redundant trains (Trains A and B) of equipment required to achieve safe shutdown.

TVA also analyzed the potential for MSOs. Section 3.9 of this safety evaluation further discusses MSOs.

3.3.3 Alternative Shutdown Conclusion

Based on its review of the information submitted by TVA, the NRC staff concludes that the alternative shutdown system is consistent with Sections III.G.3 and III.L of Appendix R to 10 CFR Part 50, and therefore, is acceptable.

3.4 Alternative Shutdown Performance Goals

TVA stated that the alternative shutdown system described in Sections 3.4.1 through 3.4.5 was designed to enable the achievement of alternative shutdown performance goals outlined in Section III.L of Appendix R to 10 CFR Part 50.

3.4.1 Reactivity Control

Initial reactivity control is provided by the control rods, which are inserted by the reactor protection system. Additional shutdown margin is provided by injecting borated water from the RWST into the RCS via the charging pumps. Source range monitoring instrumentation is available in the ACR to monitor reactivity and to ensure adequate shutdown margin.

3.4.2 Reactor Coolant Inventory

Control of the RCS inventory requires maintaining the reactor coolant pump (RCP) seal integrity and RCS pressure boundary integrity and providing RCS makeup and letdown.

RCP seal cooling is required to maintain seal integrity and to prevent an uncontrolled loss of reactor coolant inventory. Diverting a portion of the charging flow to the RCP seals achieves RCP seal cooling. Isolating the normal and excess letdown lines, in turn, isolates the RCS pressure boundary. To prevent depressurization of the RCS, the plant ensures that the solenoid valves in the reactor vessel head vent system remain closed.

RCS inventory is controlled by varying charging and letdown flow through RCS makeup and letdown paths. One of the redundant centrifugal charging pumps is required to provide makeup inventory to the RCS. The VCT is required to provide a short-term supply of water for makeup of RCS inventory and RCP seal cooling. A suction path from the RWST is required to provide a long-term source of borated water for RCS makeup. If necessary, inventory may be removed from the RCS by way of the pressurizer PORVs, discharging to the pressurizer relief tank (PRT), or discharging through the RCS head vent valves.

Reactor coolant makeup is usually available immediately following reactor trip from the charging system, except in a few fire locations where it is available within 75 minutes following reactor trip. TVA stated that an analysis was performed which demonstrates that makeup due to RCS leakage is not required for 75 minutes. TVA stated that for these scenarios, maintaining the RCS integrity is necessary to achieve adequate inventory control. The inadvertent opening of boundary isolation valves, such as the reactor head vent valves and RHR suction isolation valves, has been precluded, and adequate RCP seal integrity is maintained to assure safe shutdown.

3.4.3 Decay Heat Removal

RCS temperature from power operation to hot-shutdown conditions is controlled by the rate of heat removal from the reactor coolant to the secondary-side coolant and from hot shutdown to cold shutdown via direct heat transfer by the RHR system to the ultimate heat sink. During RCS cooldown to RHR entry conditions, heat will be removed from the reactor and transferred to the SGs via natural circulation. The removal of decay heat for cooldown from reactor trip to hot standby conditions requires one AFW pump supplying water to two of the four SGs. The required makeup water supply can come from either the condensate storage tank (CST) or from ERCW.

The CST is normally aligned to the suction of the AFW pumps. WBN is supplied with two motor-driven AFW pumps per unit with only one per unit required for safe shutdown. The turbine-driven AFW pump (one per unit) is designed to deliver a sufficient flow to all four SGs and maintain SG water levels at the lower limit of the wide range level indicator.

The RHR system is required to provide the long-term heat removal capability necessary to establish and maintain cold-shutdown conditions. The establishment of RHR cooling requires one RHR pump, a heat exchanger, and the associated flowpath to provide RCS coolant flow to the primary side of the RHR heat exchanger; one CCS pump and its associated flowpath to provide cooling to the secondary side of the RHR heat exchanger; and one ERCW pump and its associated flowpath to supply cooling water to the CCS heat exchanger. If the diesel generators are required to supply required power, an additional ERCW pump would be required for cooling purposes.

TVA's post-fire shutdown analysis states that the pressurizer heaters are the preferred method of controlling RCS pressure, and will be used if available. If the pressurizer heaters are not available, RCS pressure can be controlled by controlling pressurizer level using the charging system.

3.4.4 Process Monitoring

Direct indication of process variables including reactor coolant hot-leg temperature (T-hot), reactor coolant pressure, pressurizer level, SG level and pressure, source range flux, charging header pressure and flow, VCT level indication, and decay heat removal system flow are provided in the ACR.

TVA requested a deviation to Appendix R requirements for instrumentation necessary to achieve alternative shutdown. Specifically, contrary to Appendix R requirements, TVA has not provided wide-range SG level, tank level indication for the condensate and RWSTs, and RCS cold-leg temperature (T-cold). Section 6.1.1 of this evaluation provides the NRC staff evaluation of this deviation.

3.4.5 Support Functions

The FPR and the associated shutdown logic diagram (FPR Figure III.5) identify the emergency power distribution system, offsite power system, ERCW system, CCS, HVAC to areas containing essential FSSD equipment, and control room chillers as required support functions.

TVA stated that this essential HVAC is provided for the control, auxiliary, diesel generator, and reactor buildings. Portions of the systems in each building that service safe shutdown equipment required for compliance with Appendix R have been analyzed to ensure that at least one path of the required systems will be available for an Appendix R fire. These systems include the primary safety-related portions of the control building, the auxiliary building HVAC system for the 480V transformer rooms and for the general floor area on the 713.0 foot elevation, the turbine-driven AFW pump room, the diesel generator HVAC systems including the diesel generators, associated batteries and electrical boards and the containment air cooling systems. All other areas of the plant which contain equipment required for safe shutdown per Appendix R have been evaluated and determined that acceptable temperatures will be maintained for the required equipment to perform its intended function if HVAC is lost.

3.4.6 Alternative Shutdown Performance Goals Conclusion

Based on its review of the information submitted by TVA, the NRC staff concludes, with the exception of items evaluated elsewhere in this evaluation that TVA's treatment of alternative shutdown performance goals is consistent with Section III.L of Appendix R to 10 CFR Part 50, and therefore, is acceptable.

3.5 Operator Manual Actions

TVA's post-FSSD analysis, and associated cable interaction studies, identified some fire areas where operator actions to take manual control of equipment may be required to compensate for fire-induced equipment failures. TVA classified OMAs into two general categories: (1) manual actions for safe shutdown success path SSCs and (2) manual actions for SSCs important to safe shutdown. Repairs for cold shutdown are also included, but are not considered OMAs.

TVA referenced Revision 2 to RG 1.189 for the discussion of safe shutdown success path SSCs and SSCs important to safe shutdown.

3.5.1 OMAs for Safe Shutdown Success Path SSCs

In FPR Part V, Section 2.0, TVA stated that OMAs for SSCs in the safe shutdown success path U1
require prior NRC approval. The position that OMAs for SSCs in the safe shutdown success U2
path require prior NRC approval is consistent with the guidance in Revision 2 to RG 1.189. WBN
Unit 1 OMAs for success path SSCs were approved in NRC SSER 18, prior to operation of U1
Unit 1. The TVA evaluations of WBN Unit 2 OMAs for success path SSCs are included in FPR
Part VII, Section 8. Section 6.1.9 of this evaluation provides the NRC staff evaluation of these U2
OMAs.

TVA stated that future safe shutdown success path SSCs OMAs, or such OMAs for WBN Unit 1
implemented since the SSER 18, will be submitted to the NRC for approval, consistent with the U1
language in the FPR.

3.5.2 OMAs for SSCs That Are Important to Safe Shutdown

In FPR Part V, Section 2.0, TVA stated that OMAs for SSCs that are important to safe shutdown do not require prior NRC review and approval. The position that OMAs for SSCs that are important to safe shutdown do not require prior NRC approval is consistent with the guidance in Revision 2 to RG 1.189. Area-specific evaluations for any area where WBN Unit 2 OMAs involving important to safe shutdown equipment that are need to be performed in the area of fire origin are evaluated in Section 3.5.6 below.

TVA discussed the feasibility and reliability analysis criteria for evaluating OMAs. In FPR Part V, Section 2.1, TVA stated that these criteria are based on NUREG-1852.

For all important to safe shutdown SSC manual actions, TVA considered defense-in-depth features, such as fire prevention (transient combustible and hot work controls), fire detection and suppression, and area separation. For any area crediting an OMA with less than 2 hours of required time, and that also lacks robust defense-in-depth fire protection features; additional time margin is included in addition to the nominal acceptance criteria.

TVA considers the following factors in its evaluation of these OMAs: (1) time, (2) environmental factors (smoke, lighting, noise, etc.), (3) necessary equipment, (4) procedures, and (5) staffing. Each of the factors included acceptance criteria. For example, all OMAs have an allowable time of 10 minutes or greater with 100 percent margin. Factors that could cause delays in the performance of the OMA have also been considered. Factors such as lighting and communications are supported by plant calculations.

TVA evaluated the access routes necessary to perform the OMAs. Because some areas of the plant are separated into separate AVs, it is possible that OMAs may occur in a portion of a fire area that is remote to the portion where fire damage could affect safe shutdown equipment. In this event, additional access routes have been evaluated. TVA walked down these alternative access routes and determined that they are viable.

TVA used current NRC guidance to develop acceptance criteria for OMAs for SSCs that are important to safe shutdown. TVA incorporated a review of defense-in-depth, feasibility, and reliability in their analysis.

Based on its review of the submitted information, the NRC staff concludes that OMAs for SSCs important to safe shutdown include consideration of defense-in-depth, feasibility, and reliability, and therefore, this approach is acceptable.

3.5.3 OMAs Required Prior to Control Room Evacuation

The only operator action normally credited prior to MCR evacuation is a reactor trip (scram). However, the FPR credits two actions prior to MCR evacuation: (1) closing the two pressurizer PORV block valves and (2) tripping the RCPs. TVA stated that closing the PORV block valves is needed to prevent loss of RCS pressure/inventory due to possible spurious PORV opening prior to transferring plant control to the ACR. Also, an immediate trip of the RCPs is necessary to prevent overcooling caused by a spurious actuation of pressurizer spray valves, whose circuits are not isolated from the control building.

TVA evaluated the feasibility and adequacy of the proposed approach for performing three distinct actions prior to MCR evacuation: (1) scram, (2) PORV block valve closing, and (3) RCP trip. The evaluation assumed that a fire in the MCR would be characterized by slow growth and be detected in its early stages by control room operators or installed smoke detection systems. Fires in other areas of the control building may require MCR evacuation; such as in the cable spreading room or auxiliary instrument room, etc. The control building areas other than the MCR have installed detection and automatic suppression systems, or have a deviation documented in FPR Part VII, Section 2.3. TVA stated that areas of the control building that don't have automatic suppression typically have low combustible loading.

In NRC question RAI FPR V-16, the NRC staff expressed a concern that a fire in portions of the control building that lack fire detection and automatic suppression could impact equipment important to safe shutdown. In TVA's letter dated August 5, 2011 (ADAMS Accession No. ML11224A052), TVA stated that the PORV block valve controls are only routed through control building areas that have detection and automatic suppression. Other circuits routed through the control building are either routed through areas with fire detection and automatic suppression, or areas with detection and limited combustibles and ignition sources.

Based on its review of the submitted information, the NRC staff concludes that TVA considered the credible fire scenarios, and the installed defense-in-depth features to determine that these three control room actions are feasible, therefore, the performance of these three distinct actions is acceptable.

3.5.4 Safe Shutdown Procedures and Manpower

TVA developed a fire response procedure, Abnormal Operating Instruction (AOI)-30.1, "Plant Fires," which describes operator response and mitigating actions for plant fires. TVA also developed room-specific procedures as part of AOI-30.2, "Fire Safe Shutdown," for rooms where OMAs may be required to mitigate damage to plant safe shutdown equipment. AOI-30.2 is supported by controlled plant calculations. The procedures include operator-by-operator actions for a fire in any room of the plant that would require OMAs to shutdown the plant.

TVA has walked down the OMAs for both WBN Unit 1 and WBN Unit 2. OMAs needed after 2 hours into the fire were not walked down, since 2 hours corresponds to the time frame for additional personnel to be called to the plant in response to an event. TVA postulates that significant plant fires are interior to the plant; therefore, operators who are called back are not expected to have difficulty getting to the plant.

TVA stated that the start of the time "clock" for the performance of OMAs is the tripping of the plant. Prior to tripping the reactor, the plant is considered to be in a stable operating condition. Once the trip is initiated, the clock starts and preventive OMAs are performed to prevent spurious equipment operation and to ensure safe shutdown can be accomplished.

Most OMAs are preventive, however, some reactive OMAs must be taken upon fire damage to SSCs rather than reactor trip. TVA stated that for these reactive type actions, the normal plant operating procedures provide an appropriate reactive response to fire damage. TVA analyzed the available FSSD equipment on an area by area basis to assure that sufficient safe shutdown equipment is free of fire damage.

Based on its review of the submitted information, the NRC staff concludes that TVA's safe shutdown procedure structure, including both preventive and reactive OMAs, has been evaluated to ensure safe shutdown capability, and therefore, is acceptable.

3.5.5 Repairs

TVA stated that repair activities (e.g., lifting/cutting leads, installing jumpers, and fuse replacement) are not required to achieve and maintain hot standby conditions. TVA identified the following three generic repairs to be performed to achieve cold shutdown:

- Loading Two ERCW Pumps on 6.9 kV Board 1-BD-211-A-A,
- RHR Room Cooler Repair, and
- RHR/RCS High-Low Pressure Boundary Valve Repair.

Cold-shutdown repair activities include the installation of electrical jumpers, and the installation of replacement cables and components if needed due to fire damage. TVA has identified the specific activities to be performed and has developed repair procedures to implement this capability. Additionally, materials necessary to accomplish the repairs are available on site.

Based on its review of the submitted information the NRC staff concludes that the repair activities developed by TVA to achieve cold shutdown conditions are consistent with the requirements in Appendix R to 10 CFR Part 50 and therefore, are acceptable.

3.5.6 Unit 2 OMAs Involving Fire Area Re-Entry

TVA examined Unit 2 OMAs that involve re-entry into plant fire areas. This section discusses actions involving important to safe shutdown equipment, whereas Section 6.1.9 of this evaluation addresses OMAs involving equipment required for safe shutdown.

TVA has indicated that all WBN Unit 2 rooms that involve re-entry to perform OMAs for important to safe shutdown equipment are equipped with fire detection and automatic suppression. In addition, TVA stated that all such OMAs have approximately 60 minutes or more of time margin for the licensee staff to extinguish the fire and to operate the equipment within the room. TVA has determined that the equipment within the room of fire origin is unlikely to be damaged such that the equipment could not be operated following a postulated fire in that room. TVA has performed feasibility and reliability evaluations of the OMAs.

Based on its review of the submitted information, the NRC staff concludes that there is sufficient defense-in-depth available, detection and automatic suppression is installed, and that the manual action provides sufficient margin to assure safe shutdown capability. Therefore the NRC staff concludes that such re-entry into rooms to perform OMAs involving important to safe shutdown components is acceptable.

3.6 Associated Circuits

TVA examined the potential impact of fire damage on associated circuits of concern. TVA has categorized associated circuits as follows:

- Type I – common power source,
- Type II – spurious actuation, and
- Type III – common enclosure.

TVA stated that it identified these associated circuits of concern in accordance with GL 81-12, the NRC staff's clarification to GL 81-12, and GL 86-10.

3.6.1 Circuits Associated by Common Power Source

TVA stated that, for circuits associated by a common power source, it has identified all circuits supplied from a power source (i.e., switchgear, MCCs, and load centers) that also powers a circuit of equipment required for post-FSSD. For the identified circuits, it verified the coordination of electrical protection devices (e.g., fuses, circuit breakers, or relays) to ensure that a fire-induced fault on a branch circuit of a required supply will be cleared by at least one branch circuit protective device before the fault current can propagate to cause a trip of any feeder breaker upstream of the required supply.

In its letter dated August 5, 2011 (ADAMS Accession No. ML11227A257), in response to the RAI FPR III-17, TVA stated that a list of the design change packages has been issued to ensure that the WBN Unit 2 circuits are adequately protected with fuses/breakers to address common power supply and common enclosure associated circuits of concern. Additionally, the plant will implement these design change packages in accordance with their associated system turnover schedule and implement them before the associated system being declared operable to support WBN Unit 2 fuel load or startup.

TVA evaluated circuits associated by a common power source for multiple high impedance faults (MHIFs). TVA stated that MHIFs are evaluated in accordance with the base case conditions in Appendix B.1 to Nuclear Energy Institute (NEI) 00-01, "Guidance for Post Fire Safe Shutdown Circuit Analysis," Revision 2, issued May 2009, as endorsed by Section 5.5.2 of Revision 2 to RG 1.189. The base case set of conditions, if met, provides reasonable assurance that MHIFs will not occur. The FPR, Part III, Section 7.4, analysis provided the NEI 00-01 base case conditions with the corresponding WBN compliance method for each base case condition. The

FPR stated: "WBN meets the NEI 00-01, Appendix B.1 base case criteria which establish applicability of the base case to individual plant designs." WBN did not take any exceptions to the base cases. In a letter dated June 27, 2012 (ADAMS Accession No. ML12181A531), TVA provided a list of supporting calculations for the FPR, Part III, Section 7.4, MHIF analysis.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's method of evaluating circuits associated by a common power source is consistent with the NRC guidance in the GLs identified in Section 3.6 above, and in Appendix B.1 to NEI-00-01, as endorsed by RG 1.189; and therefore, is acceptable.

3.6.2 Circuits Associated by Spurious Operation

TVA stated that cables that are not part of safe shutdown circuits may be damaged by the effects of postulated fires. This cable damage may consequently prevent the correct operation of safe shutdown components, or result in the maloperation of equipment which would directly prevent the proper performance of the safe shutdown systems. The effects of spurious operations may be conceptually divided into two subclasses as follows:

(1) maloperation of safe shutdown equipment due to control circuit electrical interlocks between safe shutdown circuits and other circuits (e.g., the numerous safe shutdown equipment automatic operation interlocks from process control and instrument circuits)

(2) maloperation of equipment that is not defined as part of the safe shutdown systems, but that could prevent the accomplishment of a safe shutdown function (e.g., inadvertent depressurization of the RCS or the main steam system by spurious opening of boundary valves)

TVA performed an evaluation of Appendix R to 10 CFR Part 50 events to ensure that any failure of associated circuits of concern by spurious operation will not prevent safe shutdown. Credible electrical faults considered in the analysis included open circuit, short circuit (conductor-to-conductor), short to ground, and cable-to-cable (hot-short) including 3-phase hot-shorts for high/low pressure interface valves. The analysis also considered that the normally ungrounded 125 VDC power distribution system may become grounded due to fire damage.

TVA indicated that these Type II associated circuits of concern outside of containment are analyzed in accordance with the criteria in Sections III.G.2.a, III.G.2.b, and III.G.2.c of Appendix R to 10 CFR Part 50 as required circuits. Inside containment, the Type II associated circuits of concern are analyzed in accordance with the criteria in Sections III.G.2.d, III.G.2.e, and III.G.2.f of Appendix R to 10 CFR Part 50 as required circuits.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's approach to analyze circuits associated by spurious operation, in accordance with the sections of Appendix R to 10 CFR Part 50 listed above, is acceptable.

3.6.3 Circuits Associated by Common Enclosure

To address the common enclosure associated circuit concern, TVA evaluated all circuits that may share a common enclosure (e.g., cable tray, conduit, panel or junction box) with a circuit required by Appendix R to 10 CFR Part 50. On the basis of its evaluation, TVA concluded that the electrical protective equipment provided will ensure that electrical faults and overloads will not result in any more cable degradation than would be expected when operating conditions are below the setpoint of the electrical protective device.

TVA stated that the plant addressed associated circuits by common enclosure by ensuring that all required existing (prior to 1995) circuits in buildings with safe shutdown components are electrically protected with a fuse or breaker that will actuate prior to the jacket of existing faulted cables from reaching their auto-ignition temperature. Additionally, for new circuits, associated circuit electrical fault protection is provided to ensure that the fuse or breaker will operate prior to the temperature of the insulation reaching its insulation damage temperature.

In its letter dated August 5, 2011 (ADAMS Accession No. ML11227A257), in response to the RAI FPR III-17, TVA stated that a list of the design change packages has been issued to ensure that the WBN Unit 2 circuits are adequately protected with fuses/breakers to address common power supply and common enclosure associated circuits of concern. Additionally, these design change packages will be implemented in accordance with their associated system turnover schedule and will be implemented prior to the associated system being declared operable to support WBN Unit 2 fuel load or startup.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's methodology for assessing circuits associated by common enclosure is consistent with the NRC guidance in the GLs identified in Section 3.6 of this safety evaluation, and, therefore, is acceptable.

3.7 Current Transformer Secondaries

Section III.G.2 of Appendix R to 10 CFR Part 50 requires that fire induced open circuits be analyzed where they could prevent operation or cause maloperation of components required for post-FSSD.

If a fire at a remote location causes the secondary circuit of a current transformer (CT) to open, the event could generate ionized gases or additional fires, or both, in other locations and could propagate fire to additional fire areas.

TVA evaluated the fire hazards due to a fire-induced open circuit in the secondary circuits of CTs installed in high energy panels (i.e., 6.9 kV switchgear) of the required power systems. An evaluation of three types of CT circuits used in the auxiliary power system has been done: (1) ground fault, (2) differential relaying, and (3) protective relaying.

The CT circuits are contained in their respective panels for the Appendix R to 10 CFR Part 50 required and nonrequired 480 V switchgear and the 6.9 kV switchgear. Therefore, the fire would have to be localized in the switchgear assembly for the CT secondary circuit to be opened by a fire. This would prevent the CT circuits from causing fire propagation to other fire areas.

The 6.9 kV CT circuit that is connected to protective relaying and a current transducer is also contained within the switchgear panel. The output of the current transducer is connected to a remote indicator, and the current transducer is an electrical isolator. Additionally, the output-to-input of the current transducer has been tested for 1500V AC differential. Electrical isolation also exists for the Watt & VAR transducers used on the 6.9 kV switchgear at WBN.

The board differential relaying circuits are totally internal to the switchgear panels, except for the following three exceptions:

(1) The circuits between the 6.9 kV switchgear emergency supply feeders and the diesel generators are included in the interaction analysis as required circuits. The protective relays are designed to operate and clear these circuits in case of fire damage.

(2) The common station service transformers transformer differential relaying circuits are also included in the interaction analysis as required circuits. The current imbalance created by an open CT circuit causes the protective differential relay to open the supply circuit breaker, which removes primary power to the CT, clearing the circuit, within the time required for protective relay and breaker operation.

(3) The circuits between the 6.9 kV start and Unit Boards, are not required circuits. Similar to Item (2) above, current imbalance in the protective differential relay of the non-required circuits would open the supply circuit breaker.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's approach to evaluating the fire hazards due to fire-induced open circuits in the secondary of CTs installed in high energy panels is in accordance with Section III.G.2 of Appendix R to 10 CFR Part 50, and therefore, is acceptable.

3.8 High/Low-Pressure Interfaces

TVA stated that GL 81-12, GL 86-10, and Information Notice (IN) 87-50, "Potential LOCA at High-and Low-Pressure Interfaces from Fire Damage," dated October 9, 1987, describe special considerations for high/low pressure interfaces that are necessary to meet the requirements in Appendix R to 10 CFR Part 50.

In accordance with GL 81-12, the following information is necessary to ensure that high/low pressure boundary interfaces are adequately protected for the effects of a single fire:

(1) Identify each high/low pressure interface that uses redundant electrically controlled devices (such as two series motor operated valves) to isolate or preclude rupture of any primary coolant boundary.

(2) Identify the essential cabling for each device.

(3) Identify each location where the identified cables are separated by a barrier having less than a 3-hour fire rating.

(4) For the areas identified in (3) above (if any), provide the bases and justification.

Based on the above, TVA performed a review of the systems credited for safe shutdown to identify potential high/low pressure interfaces. These interfaces were evaluated to identify valves that, if spuriously opened, would expose low pressure piping to high pressure resulting in failure of the low pressure system.

The control system for RHR valves has been designed to prohibit opening unless the reactor coolant pressure is low enough to prevent RHR piping failure. However, if these valves opened spuriously, exposure of RHR piping to high pressure may cause failure of the RHR system piping and render the system inoperable. Therefore, the RHR/RCS isolation valves (1/2-FCV-74-1, -2, -8, and -9) are considered high/low pressure interface valves.

Excess letdown is not required for safe shutdown. However, the spurious opening of these valves could expose downstream piping to excess pressure that may cause failure resulting in the rupture of the primary coolant boundary. Therefore, the excess letdown isolation valves (1/2-FCV-62-55, and -56) are considered high/low pressure interface valves.

Normal letdown is not required for safe shutdown. However, spurious opening of these valves may cause failure to maintain RCS inventory control. Therefore, the normal letdown isolation valves (1/2-FCV-62-69A and -70A) are considered high/low pressure interface valves.

The safety injection system (SIS)/RHR interface valve with the RCS is located in piping that connects the SIS with the RHR system at a point between the RCS/RHR isolation valves. The SIS is not required for safe shutdown. However, the spurious opening of valve 1/2-FCV-63-186 along with either 1/2-FCV-74-1-A or -9-B could expose the SIS piping to damaging pressure. Therefore, this valve is considered a high/low pressure interface.

The pressurizer PORV and reactor head vent isolation valves are designed to function at high RCS operating pressure. They provide the following two safe shutdown functions: (1) to initially remain closed for RCS inventory control purposes and (2) to provide a means of depressurizing the RCS to the point that the RHR system can be initiated to bring the plant to a cold shutdown condition. Discharge from the RCS through these valves is directed to the inlet of the PRT. The inlet lines are sized to accommodate vent/relief discharge flow without piping or component failure. Continuous letdown to the PRT may eventually cause spillage of excess coolant to containment through the PRT rupture disks. Therefore, the pressurizer PORVs and block valve combinations, and reactor head vent isolation valves, are required for RCS inventory control (and RCS letdown) and are considered high/low interface valves.

To prevent fire-initiated cable faults from causing a spurious operation of the RHR isolation valves, all four of the motor operated valves in the RHR suction line will be kept closed (pre-fire condition) with the corresponding MCC breaker in the open position. The return lines are isolated by two series check valves in each line and a common motor-operated valve.

In its letter dated May 30, 2012 (ADAMS Accession No. ML12153A374), TVA stated that procedural controls for isolation of all potentially spurious RCS letdown paths, including pressurizer PORVs and reactor head vents, provide assurance (through the use of MCR actions for WBN Unit 2 and MCR actions and an OMA for WBN Unit 1), that isolation of normal and excess letdown paths will be achieved.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's approach for high/low pressure interfaces meets the requirements in Appendix R to 10 CFR Part 50 and follows the guidance in GL 81-12 and GL 86-10, and IN 87-50, and therefore, is acceptable.

3.9 Assessment of Multiple Spurious Operations

In FPR Part III, Section 11.0 "Multiple Spurious Operation (MSO) Evaluation," TVA stated that U1
Revision 2 to RG 1.189 formalized the requirements for addressing multiple fire induced circuit U2
failures, or MSOs and multiple concurrent hot shorts. TVA further stated that this process was U1

followed to address fire-induced spurious failures for WBN Unit 1. In a letter dated August 20, 2010 (ADAMS Accession No. ML102360283), TVA stated that the MSO scenarios requiring resolution for WBN Unit 1 would be implemented under the timing requirements prescribed by the NRC in Enforcement Guidance Memorandum 09-002, "Enforcement Discretion for Fire Induced Circuit Faults." U1

In TVA MSO Evaluation R-1976-20-001, "Watts Bar Nuclear Plant Unit 2 Multiple Spurious Operation Evaluation, Revision 1" (ADAMS Accession No. ML103160419), TVA stated that multiple fire-induced spurious failures were evaluated at WBN Unit 2 as described in Revision 2 to RG 1.189. TVA further stated that, based on the results of the MSO expert panel conducted at the plant for WBN Unit 1, various scenarios were identified and were reviewed for WBN Unit 2. Appendix B, "Unit 2 Resolutions," and Appendix C, "Unit 1/Common Resolutions," of the above report provided resolutions for specific unresolved MSO scenarios that affect WBN Unit 2. U2

In a letter dated February 7, 2013 (ADAMS Accession No. ML13044A114), TVA stated that the above MSO scenarios requiring resolution for WBN Unit 1 have been resolved and incorporated into Appendix B and Appendix C to Revision 2 to MSO Evaluation R-1976-20-001. U1

In Section 4 of the MSO Evaluation (Revisions 1 and 2), TVA stated that MSO scenarios selected for Sequoyah Nuclear Plant, Units 1 and 2, and for WBN Unit 1 were evaluated to determine if the scenarios were applicable to WBN Unit 2 and how Unit 2 complied with each scenario. Sequoyah Nuclear Plant, Units 1 and 2, and WBN Units 1 and 2, have similar physical and systems designs. All four units are Westinghouse four-loop pressurized water reactors with wet ice condenser containments and would be expected to have similar MSO scenarios. Additionally, the Sequoyah Nuclear Plant, Units 1 and 2, MSO scenarios were analyzed from a dual unit perspective. U2

Based on its review of the information submitted by TVA, the NRC staff concludes that by evaluating multiple fire-induced spurious failures in accordance with the guidance in Revision 2 to RG 1.189 and by using MSO scenarios from Sequoyah Nuclear Plant, Units 1 and 2, and WBN Unit 1 when addressing WBN Unit 2 and dual-unit scenarios, TVA's approach is an acceptable means for addressing MSO failures.

3.10 Smoke Control and Ventilation

FPR Part VIII, Section D.4, and FPR Part X, Section 3.2.9, discuss smoke control and ventilation. TVA stated that plant ventilation systems at WBN are not specifically designed to exhaust smoke or corrosive gases. TVA further stated that a combination of the normal ventilation exhaust systems and portable fans are used to remove smoke from specific rooms during and after fire-fighting activities. Non-recirculating ventilation systems are provided for fire areas that may contain airborne radioactive materials. Smoke from fires that might occur in areas containing radioactive materials is monitored for radioactivity.

Based on its review of the information submitted by TVA, the NRC staff concludes that smoke control and ventilation for fire protection purposes at WBN are installed consistent with Position D.4 of Appendix A to BTP APCSB 9.5-1, and, therefore, is acceptable.

3.11 Lighting and Communications

TVA stated that fixed, self-contained lighting consisting of sealed-beam units with individual 8-hour minimum battery power supplies are provided in areas that must be manned for safe shutdown, and in access and egress routes to and from all fire areas containing equipment required for safe shutdown. TVA stated that plant walkdowns have been conducted during "blackout" conditions to assure the adequacy of the lighting. These walkdowns were used to document the adequacy of the lighting levels. Functional and visual testing of the fixed emergency lighting units is also performed to assure that the emergency lights provide their minimum 8-hour availability.

In FPR Part VII, Section 2.7, TVA requested to deviate from its emergency lighting criteria inside the reactor building, yard area, and the turbine building. Section 6.1.6 of this evaluation provides the NRC staff's evaluation of this deviation.

Based on its review of the submitted information, the NRC staff concludes, with the exception of items evaluated elsewhere in this evaluation, that the emergency lighting is consistent with the requirements in Section III.J of Appendix R to 10 CFR Part 50 and the guidelines contained in Section D.5.a of Appendix A to BTP (APCSB) 9.5-1 and therefore, is acceptable.

TVA provided several means of communication to support safe shutdown operations including (1) telephones, (2) a code, alarm, and paging system, (3) sound-powered phones, (4) cellular phones, and (5) two-way radios. The in-plant radio repeater system is the primary means of communication for performing manual shutdown actions and for fire brigade fire-fighting operations. The repeater system consists of very high frequency radio repeaters, remote control units, portable radios, and redundant antenna systems.

Operations and maintenance personnel primarily use these radios; however, the plant designates one channel of the in-plant radio system for use by the fire brigade during fires or other emergencies. Redundant fixed repeaters are widely separated so that a fire that also necessitates manual actions will not affect redundant repeaters. Some plant areas lack full radio coverage; however, coverage is available immediately outside of these rooms. Sound-powered phones are available in the ACR and local stations that are needed for alternative shutdown. Cell phones are available to supplement the communication system.

Based on its review of the submitted information, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, TVA's means of communications do not take any exceptions to Positions D.5.c and D.5.d of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

4.0 FIRE PROTECTION SYSTEMS

4.1 Water Supply and Distribution

TVA described the fire water supply system at WBN in FPR Part II, Section 12.1, "Water Supply." TVA also described the system in its response by letter dated August 5, 2011 (ADAMS Accession No. ML11224A052), to RAI FPR II-45. TVA stated that the high pressure fire protection (HPFP) water system is common to both units, and that it consists of four electric motor driven pumps and one diesel engine driven pump.

TVA stated that the electrically driven pumps are seismic Category I high-pressure vertical turbine motor-driven pumps in accordance with Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code). Each pump is rated at 1,590 gallons per minute (gpm) at 130 pounds per square inch, gauge (psig). TVA calculated the maximum required fire water demand based on the largest automatic suppression system demand and hose streams, and it stated that each of these pumps can supply 50 percent of the required flow. The pumps are located in the seismic Category I intake pumping station (IPS) with a 3-hour-rated fire barrier that separates two fire pumps from the other two fire pumps.

TVA stated that a 100 percent capacity, UL listed, diesel fire pump is remotely located in the yard near the Unit 1 cooling tower. TVA stated that the diesel fire pump is capable of developing a flow of 2,500 gpm (100 percent capacity) at 125 psig and 3,750 gpm (150 percent capacity) at 81 psig.

TVA stated that the water supply for the electric fire pumps is taken from the Tennessee River and the diesel fire pump takes its water from the WBN Unit 1 cooling tower basin. TVA stated that the Tennessee River is essentially unlimited, and that the WBN Unit 1 cooling tower basin can provide a minimum of 2 hours supply at 150 percent of the capacity of the diesel pump.

TVA stated that the electric pumps are automatically started by activation of the fire detection systems associated with installed automatic water based suppression systems. Also, the electric pumps can be started manually from either the MCR or the appropriate 480 V shutdown board. The diesel pump automatically starts on low system pressure or can be manually started from the MCR.

TVA stated that each electric fire pump is powered from a separate 480 V shutdown board, and that in the event of loss of offsite power, each 480 V shutdown board is automatically connected to a separate emergency diesel generator. Supervised alarm circuits, indicating fire pump motor running condition and loss of line power on the line side of the switchgear, are provided in the MCR for each electric pump. The diesel fire pump also sends annunciation signals to the MCR.

TVA stated that the electric fire pumps also serve as a backup water supply to the AFW system in the event of a flood above plant grade (called "flood mode"). TVA stated that, as a result, this requires the use of pumps that meet the requirements in Section III of the ASME Code as opposed to traditional fire pump installations that are UL listed or factory-mutual-(FM)-approved pumps in accordance with NFPA 20-1993, "Standard for the Installation of Centrifugal Fire Pumps," for electric driven pumps. In FPR Part VII, Section 5.1, TVA stated the following:

(1) Pump curve verification tests have been performed to include multiple diverse points on the pump curve to replicate fire pump test requirements as opposed to the single point verification applicable to ASME Code Section III pumps;

(2) TVA performed hydraulic calculations to demonstrate that the pumps provide adequate flow and pressure to the most hydraulically remote suppression systems;

(3) The electrical circuits for pump power and control meet IEEE Class 1E standards and, even though the pumps do not start on pressure drop in the piping system, they do start on activation of the fire detection systems associated with pre-action suppression systems; and

(4) The fire pumps can only be manually stopped from the MCR or in the IPS (where the pumps are located).

Based on the above submitted information, the NRC staff concludes that, while not designed to the guidelines in NFPA 20, the electric fire pump configuration will not negatively affect the performance of the fire protection system, and meets the purpose of the guidelines of Section E.2.c of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

TVA stated that the diesel fire pump installation and its associated controller are installed in accordance with NFPA 20-1993. Based on the information submitted by TVA that states that the diesel fire pump and associated controller are installed in accordance with NFPA 20-1993, the NRC staff concludes that the installation of the diesel fire pump is acceptable.

TVA stated that a self-cleaning strainer capable of handling 100 percent flow is provided on the discharge side of each pair of electric fire pumps. The strainers are located in the IPS and conform to the requirements in Section III of the ASME Code for seismic Category I components. For the diesel fire pump, TVA stated that mechanical screens are provided on the supply side and a strainer on the discharge.

TVA stated that the HPFP system is interconnected to the raw cooling water (RCW) system. Automatic isolation valves are provided to isolate the RCW system and selected RCW loads from the HPFP system when any fire pump is started to reduce the RCW load on the HPFP system to ensure adequate flow and pressure are available. During normal operation, HPFP system pressure is maintained by the RCW pumps.

The HPFP system mains consist of both cement lined iron yard mains and unlined steel safety headers. The steel safety headers serve as a backup water supply to the AFW system in "flood mode," as noted above. TVA stated that the details of the "flood mode" are documented in several places in the FSAR, for example, FSAR Section 2.4.14.2, "Plant Operation During Floods Above Grade." The piping inside buildings is unlined steel. The buried steel piping has an exterior coating to prevent corrosion. The electric fire pumps feed the steel headers and the diesel pump feeds the iron yard main. The two loops (iron and steel) are connected at the IPS (via normally open valve 0-FCV-26-17) and at two remote points in the auxiliary building (via normally open valves 0-FCV-26-15 and 0-FCV-26-16). TVA stated that pressure control is provided by a pressure control valve downstream of the four electric pumps.

TVA stated that sectional isolation valves are provided on the iron yard main to allow maintenance on portions of the system while the plant maintains its fire-fighting capability. In addition, TVA stated that the sectional isolation valves in the underground and building loops are locked or sealed in position and that surveillance is performed to ensure proper system alignment. The plant has not installed any sectional valves on the steel safety header. Because the two headers are redundant and because they are also connected to the iron yard main through valves in the turbine building, the plant could isolate either main and would still have two sources of fire water available.

TVA stated that all post-indicator-type valves are either sealed or locked open with a key-operated "breakaway" type lock. TVA further states that curb box valves are not locked open, but TVA considers these valves to be tamper resistant because they cannot be operated without a special "key" tool that is not generally available.

In the FPR, TVA stated that the WBN fire water supply system as being able to provide the designed fire-fighting capacity either with one electric pump and the diesel pump unavailable or with the hydraulically least demanding portion of any loop main out of service. TVA further stated that the design flow demand consists of design flow to the largest sprinkler or water spray system plus design flow to non-isolated RCW loads and 500 gpm for hose streams.

TVA stated that suppression systems and hose station standpipe systems are separately connected to the yard main or to headers within buildings and are fed from each end of the building, so that a single failure cannot impair both suppression systems and hose stations at the same time.

As result of the concern with microbiologically induced corrosion (MIC) and other corrosion issues, TVA has instituted a permanent monitoring program for assuring the performance of the standpipe and suppression systems. TVA stated that this testing is performed at the hydraulically most remote hose stations every 3 years. TVA uses the calculated design basis pressure and flow requirements for these hose stations as the basis to monitor system performance.

TVA's design calculation reduces the actual pipe inside diameter by 0.8 inches and uses a Hazen-Williams C factor of 55 for the sections of piping that are normally wetted. TVA stated that the purpose of these piping restrictions and the C factor of 55 are to account for the 40-year service life of the pipe. The data collected from these tests will be compared to the calculated values and trended to detect system failure.

TVA stated that all raw water systems, including HPFP, are chemically treated in a manner that is consistent with nuclear industry practice. TVA stated that this treatment includes oxidizing biocide, non-oxidizing biocide, phosphate, and zinc. TVA further stated that the oxidizing and non-oxidizing biocides are used to control Asiatic clams, zebra mussels, slime, and MIC; the phosphate is used to sequester iron from existing corrosion products; and the zinc acts as a mild corrosion inhibitor for the carbon steel surfaces. As described in TVA's letter dated August 5, 2011 (ADAMS Accession No. ML11224A052), in response to RAI FPR VII-2.1, the non-oxidizing biocide treatments are coordinated with periodic system flushes in order to distribute the biocide to normally stagnant portions of the system.

TVA stated that two programs have been implemented to combat pipe corrosion. First, TVA implemented the Corrosion Control Program, which primarily monitors pipe wall thickness using ultrasonic techniques, replacing lengths of pipe when minimum wall thickness cannot be maintained. Additionally, TVA stated that a WBN Buried Piping Plan has been established in support of NEI 09-14, "Guideline for the Management of Underground Piping and Tank Integrity." TVA described this program as providing for the risk ranking of buried piping relative to installed conditions (e.g., design and construction practices, as well as soil characteristics) and consequences of a failure of the piping. TVA stated that these programs are intended to provide assurance in the integrity of the HPFP system boundaries.

In addition, TVA performed a code compliance review against NFPA 24-1973,"Outside Protection," as documented in FPR Part X. No substantial exceptions were identified.

Based on its review of the submitted information, the NRC staff concludes that, with the exception of the system design demand, the fire water supply system conforms to the guidelines of Sections E.2 and E.3.a of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

Regarding the system design demand, the NRC staff concludes that it conforms to the NRC's current guidance found in Position 3.2.1 of RG 1.189, Revision 2, and, therefore, is acceptable.

4.2 Active Fire Control and Suppression Features

4.2.1 Automatic Fire Suppression Systems

4.2.1.1 Sprinklers and Fixed Spray Systems with Closed Heads

In FPR Part III, Section 10.3.1, TVA stated that all AVs that contain redundant safe shutdown equipment are protected to ensure that the plant maintains its safe shutdown capability. In most cases, the means of protection is consistent with Section III.G.2 of Appendix R to 10 CFR Part 50. For instance, in areas in which cables of redundant safe shutdown equipment are located in an AV and could be damaged by fire, the plant ensures the function by installing a 1-hour ERFBS on one train with automatic fire detection and suppression or by installing a 3-hour ERFBS in areas that do not provide fire detection and suppression. TVA also stated that, if separation between rooms in the same fire area is less than 3 hours rated, the plant either provides automatic detection and suppression systems or identifies and justifies deviations.

Where deviations from Section III.G.2 requirements exist, with respect to coverage of suppression and detection systems, TVA performed evaluations to demonstrate that an adequate level of protection is provided. Section 6.1.7 of this evaluation provides the NRC staff evaluation of these deviations.

In FPR Part VII, Section 2.4, TVA described a methodology used to resolve situations where redundant trains are separated by more than 20 feet, but without 20 feet free of intervening combustibles. Section 6.1.4 of this evaluation provides the NRC staff evaluation of this configuration.

Where provided, TVA stated that sprinkler systems and fixed water spray systems are designed in accordance with the applicable requirements in NFPA 13-1975,"Standard for Installation of Sprinkler Systems," and NFPA 15-1973, "Standard for Water Spray Fixed Systems."

In addition, TVA performed a code compliance review and identified several areas in which the sprinkler and fixed spray systems differed from the code. The important exceptions to the NFPA 13-1975 code identified were as follows:

- Fire department pumper connections for the sprinkler system are only provided to buildings with one connection to the underground fire main. (NFPA 13, Section 2-7). The NRC staff concludes that this arrangement meets the intent of the provision.

- Strainers are provided in the supply to each pre-action sprinkler system in lieu of following flushing requirements. (NFPA 13, Section 3-37.3.) The NRC staff concludes that this arrangement meets the intent of the provision.

- Sprinklers are not provided below the open grating above the high-pressure fire pump flow control valve on elevation 692 feet in the Unit 1 penetration room (Room 692.0-A7). TVA stated that the combustible loading in this fire area is insignificant. This grating is approximately 5 feet wide by 15 feet long and is 15 feet above the room floor. Two sprinklers are installed approximately 3 feet above the grating. Plant procedures prohibit the storage of material on these grated walkways, so the gratings would be free of foreign obstructions. Due to the size of the grating (4 in. by 1 in.), flow from the sprinklers is not expected to be restricted by the grating. (NFPA 13, Section 4-4.11.) The NRC staff concludes the current sprinkler configuration in the Unit 1 penetration room is acceptable.

The NRC staff reviewed the other code exceptions from NFPA 13 that TVA proposed in FPR Section X, and determined that the exceptions will not affect the performance of the systems and, therefore, are acceptable.

With respect to NFPA 15, TVA did not take any exceptions to the code for the water spray systems protecting outdoor transformers, the hydrogen trailer, turbine hydrogen seal oil unit, or the turbine lube oil reservoir. TVA used the guidance of NFPA 13 to design the directional fusible nozzle water spray systems used to protect certain charcoal filters and the RCPs.

TVA stated that automatic pre-action sprinklers are provided in areas in which it is important to prevent accidental discharge of water. Operation of the pre-action sprinkler system is initiated by a signal from the fire detection system in the area. Actuation can also be initiated manually by mechanical operation at the deluge valve. In addition, selected pre-action systems at WBN have manual actuation stations placed at strategic locations remote from the valve. These systems are provided with air supervision if the piping downstream of the system control valve supplies more than 20 sprinkler heads.

TVA stated that, where manually activated suppression systems are installed, the piping network isolation valve is maintained in the closed position. Personnel are alerted to a problem in these areas by the fire detection system and, after confirming there is a fire, personnel open the appropriate isolation valve to allow water into the system. Water is then applied to the fire when the heat from the fire melts the fusible element in the sprinkler head. Water flow is subsequently stopped by manually closing the associated isolation valve.

In FPR, Part VIII, TVA stated that drainage is provided to remove the expected fire protection water flows or control the accumulation of water such that the water will not cause unacceptable damage to equipment in the area. TVA further stated that additional drainage can be achieved by diverting water into adjacent rooms. Finally, TVA stated that water draining from areas which may contain radioactivity is sampled and analyzed before being discharged into the environment.

TVA stated that standpipes, hose stations, and portable fire extinguishers are provided throughout the control building, but that fixed fire suppression systems are not provided for all rooms. TVA justified the lack of fixed automatic suppression capability by stating that the control building is a single fire area with fire detection provided throughout the control building except in certain areas, and that there are no alternative shutdown cables or equipment located in the control building, thereby satisfying the design intent of maintaining safe shutdown capability for a postulated fire event by providing an alternate design concept. Based on TVA's justification, the NRC staff concludes TVA's approach to be acceptable. See Section 3.3 of this evaluation for a discussion of alternate shutdown, and Section 6.1.3 for a detailed discussion of the lack of area-wide automatic suppression in the control building.

In all cases, TVA stated that an adequate level of protection is provided via a combination of limited combustible materials, administrative controls, fire rated barriers, spatial separation, and active fire protection systems. Where exceptions or deviations from NRC staff guidance, rules, or design standards exist, TVA stated that they have performed evaluations to ensure that an adequate level of protection is provided. The NRC staff reviewed TVAs approach to the use of sprinkler and water spray fire suppression systems, and concludes that TVA's design criteria and bases are consistent with Positions E.2 and E.3.c of Appendix A to BTP (APCSB) 9.5-1 and the defense-in-depth concept described in Appendix R to 10 CFR Part 50, and therefore, are acceptable.

4.2.1.2 Gas Suppression Systems

TVA stated in FPR Part II that automatic total flooding CO2 suppression systems are provided for the auxiliary instrument rooms and computer room in the control building; and in the lube oil storage room, diesel engine rooms (4), fuel oil transfer room, and 480 V board rooms (4), located in the diesel generator building.

TVA stated that the CO2 systems are designed and installed in accordance with the NFPA 12-1973,"Carbon Dioxide Extinguishment Systems," the code of record for these systems. Further, TVA stated in its letter dated March 16, 2011 (ADAMS Accession No. ML13060A403), in response to NRC question RAI FPR II-6, that the systems installed in the computer room, diesel generator electrical board rooms, lube oil storage room, and fuel oil transfer room are installed for property protection purposes only, and do not have soak time requirements. In addition, TVA stated that the systems are appropriate for the anticipated hazards and that they performed system dump tests to ensure agent concentration, agent reserve, and operability of the distribution system.

TVA stated that a signal from either the fire detection system or a push button station activates the area alarms, CO2 discharge timer, which actuates the master control valve, and the area selector valve permitting the CO2 to be discharged into the selected area. In addition, the system can be manually operated via the electro-manual pilot valve for each hazard protected on the loss of power to the system. In designing these systems, TVA has considered personnel safety by providing the pre-discharge alarm to notify anyone in the area that CO2 is going to be discharged, and by adding an odorant to the CO2 to warn personnel that the system has been discharged.

In addition, TVA stated that the actuation of these systems causes selected fire dampers and doors to the protected area to close and the HVAC fans to the area to shut down, ensuring that the minimum concentration of CO2 is maintained and preventing fire spread from the area of fire origin. TVA also stated that it has performed full discharge tests for representative rooms in conjunction with door fan pressurization tests to validate CO2 concentration and soak times.

The CO2 storage tank for supplying CO2 to systems that protect the diesel generator building is located in the diesel generator building. The diesel generators are protected from the effects of a postulated failure of this tank by an 18-inch thick reinforced concrete wall. The vent path for the tank room for the storage tank compartment is through a set of double doors that lead into a stairwell then, if needed, through another set of double doors which open to the atmosphere from the stairwell.

The CO2 for the balance of the plant is supplied from a storage tank in an underground vault in the yard. TVA stated that the system is designed such that failure of the system cannot pose a threat to any safety-related areas or structures.

The NRC staff has reviewed TVA's approach to the use of automatic CO2 fire suppression systems and concludes that TVA's design criteria and bases are consistent with Positions D.4.i and E.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

4.2.2 Manual Suppression Capability

4.2.2.1 Hose Stations

In FPR, Part II, TVA stated that hose stations for manual fire-fighting are located throughout the plant to ensure that an effective hose stream can be directed to any safety-related area in the plant. TVA further stated that the system is designed according to the requirements of NFPA 14-1974,"Standpipe and Hose System for Sizing, Spacing, and Pipe Support Requirements," except for those hose stations in certain areas of the plant in which TVA requested a deviation to exceed the 100-foot hose spacing limitation. These deviations are discussed in Section 6.2.4 of this evaluation.

In addition, TVA performed a code compliance review and identified several areas in which the manual fire-fighting hose stations and standpipe system differed from the code. TVA also performed evaluations to justify these exceptions. The significant NFPA 14 code exceptions identified and associated justifications are:

- The standpipes located on elevations 676.0 feet, 692.0 feet, 713.0 feet, 729.0 feet, 757.0 feet, 772.0 feet, and 782.0 feet of the auxiliary building are supplied by a 3-inch pipe rather than the 4-inch pipe, and elevation 755.0 feet of the control building has 2 ½-inch supply piping. TVA stated that it verified by hydraulic calculation that these pipe sizes were adequate. (NFPA 14, Section 212.)

- Two standpipes (0-26-677 and -690) are not provided with header isolation valves. TVA stated that these systems can be isolated and that this would not preclude the ability to provide hose stream coverage in the locations normally served by these standpipes. (NFPA 14, Sections 413 and 622.)

- Pressure reducing devices are not installed at the hose stations. TVA justified this by stating that the hose stations are for fire brigade use, and the fire brigade personnel are trained in the use of high pressure fire hoses. TVA further stated that the hoses and related fittings are maintained to accommodate the expected system pressures. (NFPA 14, Section 442.)

- High pressure valves, pipes, and fittings are not used, even though system spikes of up to 190 psi occur due to pump start surges. TVA stated that the piping and fittings can withstand the working pressures of the system and that the system is in accordance with American National Standards Institute B31.1, "Code for Pressure Piping," system requirements. (NFPA 14, Sections 625, 631, and 641.)

- Water flow alarms are not provided on all standpipes. TVA stated that the hose stations are provided for fire brigade use. Other site personnel are trained to report fires before using fire-fighting equipment (if they have been trained in its use). Therefore, TVA concluded that sufficient notification of standpipe use will be provided to the MCR without water flow alarms. (NFPA 14, Section 67.)

The NRC staff reviewed TVA's proposed exceptions from NFPA 14 and determined that they will not affect the performance of the hose stations and the standpipes. Therefore, the exceptions are acceptable.

In FPR, Part VIII, TVA stated that drainage is provided to remove the expected fire protection water flows or control the accumulation of water such that the water will not cause unacceptable damage to equipment in the area. TVA further stated that additional drainage can be achieved by diverting water into adjacent rooms. Finally, TVA stated that water draining from areas that may contain radioactivity is sampled and analyzed before being discharged into the environment.

TVA stated in the FPR that hose station nozzles appropriate for the expected hazards (e.g., electrically safe) are provided for each hose station. In addition, TVA stated, in FPR Part VIII, and in its letter dated August 5, 2011 (ADAMS Accession No. ML11227A257), in response to RAI FPR II-41.1 and RAI FPR VII-17.1, that provisions has been made to supply water at sufficient pressure and capacity to the standpipes, hose stations, and hose connections for manual fire-fighting in areas required for safe plant shutdown in the event of a safe-shutdown earthquake.

Based its review of the information submitted by TVA, the NRC staff concludes, with the exception of items evaluated elsewhere in this evaluation, that the standpipe system and hose stations do not take any exceptions to Positions E.3.d and E.3.e of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

4.2.2.2 Fire Extinguishers

TVA stated that portable fire extinguishers of a size and type compatible with specific hazards are strategically located throughout the plant for use by trained personnel. TVA also stated that fire brigade members and fire watch personnel have been trained on the location of extinguishers for firefighting operations through the extinguishers inspection program. In addition, TVA stated that fire extinguishers are inspected on a quarterly basis.

TVA's proposed application and strategic distribution of portable fire extinguishers throughout the plant is consistent with the guidance contained in Position E.6 of Appendix A to BTP (APCSB) 9.5-1, and provides reasonable assurance that fire extinguishers will be readily available and quickly accessed in the event of a fire emergency. Therefore, the NRC staff concludes that TVA's proposed application and strategic distribution of portable fire extinguishers is acceptable.

4.3 Fire Detection Capability

In FPR Part III, Section 10.3.1, TVA stated that all analysis volumes containing redundant safe shutdown equipment are protected to ensure safe shutdown capability is maintained. In most cases, the means of protection is consistent with 10 CFR Part 50, Appendix R, Section III.G.2. For instance, where cables of redundant safe shutdown equipment is located in an analysis volume and could be damaged by fire, the function is ensured either by the installation of 1-hour ERFBS on one train with automatic fire detection and suppression, or a 3-hour ERFBS where fire detection and suppression are not provided. TVA also stated that if separation between rooms in the same fire area is less than 3-hour rated, automatic detection and suppression systems are provided or deviations are identified and justified.

Where deviations from Section III.G.2 requirements exist, with respect to coverage of suppression and detection systems, TVA performed evaluations to demonstrate that an adequate level of protection is provided. Section 6.1.7 of this evaluation provides the NRC staff evaluation of these deviations.

In FPR Part VII, Section 2.4, "Intervening Combustibles," TVA described a methodology used to resolve situations where redundant trains are separated by more than 20 feet, but without 20 feet free of intervening combustibles. Section 6.1.4 of this evaluation provides the NRC staff evaluation of this configuration.

As described by TVA in FPR Part II, the fire detection system consists of initiating devices, local control panels, a remote transmitter-receiver providing a remote multiples function, computerized multiplex central control equipment, and a power supply. A central processor unit (CPU) of the computerized multiplex central control equipment communicates with the local control panels via the remote transmitter/receiver units over looped circuits. TVA stated that where detection is provided for the protection of safety-related or FSSD equipment, Class A, four-wire, supervised circuits link the fire detectors to the local control panels and annunciate status change to a constantly attended location. In addition, a second CPU is provided in a constantly attended location as an alternate for the primary processor.

TVA stated that the fire detection system uses photoelectric, ionization, and thermal detectors. The fire detection system also monitors duct detectors and devices for monitoring fire suppression system piping integrity, water or CO2 flow, and diesel fire pump status. The fire detection system gives an audible and visual alarm, and also annunciates in the control room.

TVA stated that, where detection systems are provided, the detection systems are designed in accordance with the applicable requirements of the NFPA 72D-1975,"Installation, Maintenance and Use of Proprietary Signaling Systems," and NFPA 72E-1974, "Automatic Fire Detectors." In addition, TVA performed a code compliance review and identified several areas in which the systems differed from the code. The significant NFPA 72D and NFPA 72E code exceptions identified were as follows:

(a) The operation and supervision of fire alarms is not the primary function of the system operators (i.e., the control room operators). The operators are responsible for all control room alarms and controlling the plant. (NFPA 72D, Section 1223.) This is acceptable to the NRC staff, because, consistent with the role and training of the operators, a fire alarm actuation is an event that will be responded to, and will not be ignored.

(b) The fire alarm console in the MCR is an UL-listed device; however, TVA modified this console by adding non-UL-listed panels known as A-B switchover panels, which allow a quick changeover to the installed spare control system. TVA stated that this option is not commercially available and does not degrade the system. The two alerting tone volume control devices have been adjusted to meet the requirements of the human factors analysis for the MCR. (NFPA 72D, Sections 1213 and 2022.)

The NRC staff concludes that this modification is acceptable because it does not diminish the ability of the system to perform its function.

(c) Actions upon receipt of a fire alarm signal; the fire brigade is not immediately notified. TVA stated that, upon receipt of an alarm from a detection system, an individual (auxiliary or fire operator) is dispatched to the area to determine the cause of the alarm. If a fire exists, the individual notifies the MCR, and control room operators notify the plant fire brigade. If both detection zones alarm of a cross-zoned detection system, the fire brigade is notified immediately. (NFPA 72D, Section 1251.) The NRC staff concludes that this arrangement is acceptable because it allows false alarms to be addressed while maintaining rapid response by the site fire brigade to actual fires.

(d) The fire alarm system uses the emergency diesel generators as the automatic secondary power supply. The uninterruptible power supply backup and batteries inside the fire alarm console supply selected devices within the console. (NFPA 72D, Sections 2223, 2224, and 2231.) The NRC staff concludes that this arrangement is acceptable because it provides a reliable source of backup electrical power.

(e) Signal attachments and circuits (pressure switches) can be removed or tampered with and not cause an alarm. The site personnel access control system and the work control system provide assurances that work on such devices is properly controlled and documented. (NFPA 72D, Section 3423.) The NRC staff concludes that this is acceptable because these devices are not installed in areas accessible to the general public, where tampering is a concern.

(f) Sprinkler system control valves are not electrically supervised; instead, the valves are locked open or sealed open and periodically inspected instead. TVA stated that administrative controls, including second party verification of position and strict site-access and work controls, will ensure that valves are in the correct position. (NFPA 72D, Section 3442.) The NRC staff concludes that this is acceptable because it provides assurance that the valves will be in the correct positions when needed.

(g) Both visual and recorded displays meet the code, but records are not preserved for later inspection. Plant procedures have reporting requirements for conditions adverse to quality. These procedures require an adverse condition report to be completed before the end of the shift on which the problem was identified. Documentation from the fire alarm printout would be available to support the adverse condition report. (NFPA 72D, Section 4111.) The NRC staff concludes that this arrangement is acceptable because it will support the reconstruction of the sequence of events.

(h) The transmission of an alarm signal to the fire alarm console from a wire-to-wire short circuit cannot be recorded. TVA stated that a wire-to-wire short will generate a trouble signal which requires corrective action and associated compensatory measures as laid out in FPR Part II, Section 14. (NFPA 72D, Sections 4112 and 4311.) The NRC staff concludes that this is acceptable because this situation initiates corrective actions and compensatory measures, which include roving or continuous fire watches.

(i) Fire detection has not been provided in the diesel generator building stairway D1, bathroom, and CO2 storage room on elevation 742 feet, and the corridor and radiation shelter room on elevation 760 feet, because a fire in these rooms would not impact the plant's ability to achieve and maintain safe shutdown. In addition, no detection capability is installed in specific auxiliary building pump room entrance labyrinths, the airlocks, and the auxiliary building elevator shaft and associated auxiliary elevator equipment. TVA stated that a fire in these areas would not have an impact on the safe shutdown capability of the plant. (NFPA 72E, Section 2-6.5.) The NRC staff concludes that this is acceptable because of the nature of the spaces (e.g., the lack of combustibles, lack of impact on safe shutdown capability.)

(j) Smoke detectors in the high ceiling areas of the plant are not installed alternately on two levels. TVA has addressed the issue of high ceilings by reducing the spacing of the detectors at the ceiling level. This reduced spacing is used on auxiliary building elevations 692 feet, 713 feet, 737 feet, 757 feet, and the waste packaging room. (NFPA 72E, Section 4-4.5.2.) The NRC staff concludes that this is acceptable because stratification is not a concern due to the ventilation system.

(k) TVA uses duct detectors in lieu of area detectors in the reactor building upper and lower compartment coolers to provide protection specifically for the coolers. TVA stated that the regulatory requirements for detectors are met for the remainder of the reactor building. (NFPA-72E, Section 8-1.1.2.) The NRC staff concludes that this is acceptable because these detectors are installed to protect these specific pieces of equipment (e.g., the compartment coolers) and not the general area.

(l) Duct detectors are not provided per NFPA 90A requirements, which require that activation of a detector automatically stops the ventilation system. Instead, fans serving the area of the plant containing the fire are shut down manually to ensure that air flow will not prevent fire dampers from closing. (NFPA-72E, Section 8-1.2.1.) The NRC staff concludes that this is acceptable because it accomplishes the goal of the provision. Additionally, the HVAC system has been designed as described in WBN Final Safety Analysis Report (FSAR) chapters 3, 6, and 9, and approved by the NRC.

The NRC staff has reviewed TVA's proposed exceptions from NFPA 72D and NFPA 72E, and has determined that they will not affect the performance of the affected systems or the ability of the plant to achieve and maintain safe shutdown. Therefore, the exceptions are acceptable. The NRC staff concludes that TVA's design criteria and bases for the installed systems are consistent with Position E.1 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

In all cases, TVA stated that an adequate level of protection is provided via a combination of limited combustible materials, administrative controls, fire rated barriers, spatial separation, and active fire protection systems. Where exceptions or deviations from NRC staff guidance, rules, or design standards exist, TVA stated that they have performed evaluations to ensure that an adequate level of protection is provided. The NRC staff reviewed TVA's approach to the use of fire detection systems and concludes that, with the exception of items evaluated elsewhere in this evaluation, TVA's design criteria and bases are consistent with Position E.1 of Appendix A to BTP (APCSB) 9.5-1 and the defense-in-depth concept described in 10 CFR Part 50, Appendix R, and, therefore, are acceptable.

5.0 FIRE PROTECTION FOR SPECIFIC PLANT AREAS AND HAZARDS

5.1 Containment

Appendix A to BTP (APCSB) 9.5-1, includes guidance for fire protection in containment. In its letter dated May 26, 1995 (ADAMS Accession No. ML073230888), TVA stated that a major fire hazard within containment is the lube oil in the RCPs. If oil leaks from the RCPs, an oil collection system is available to collect the oil for each RCP as described below. This system on each RCP is designed to collect oil from all potential leakage locations, including the RCP oil lift pump, system piping, overflow lines, the lube oil cooler, oil fill and drain lines, flanged connections on the oil lines, and the lube oil reservoirs.

The RCPs, lubricating oil systems, oil spray shields, oil collection basins, drain piping, and containment sump are designed to seismic Category I requirements so that they will not fail during a safe shutdown earthquake.

Each of the four RCPs is protected by an automatic fire suppression and detection system. A heat collection hood is installed directly above the RCP motors. In the event of an RCP motor fire, the heat collection hood acts as a ceiling, that forces the heat to stall around the detectors and the suppression nozzles, thus reducing the response time of these fire protection devices.

Section 6.1.8 of this evaluation provides the NRC staff's evaluation of the RCP oil collection system configuration and associated fire protection features.

TVA stated that areas of divisional interaction within the annulus areas are protected by automatic fixed water-spray systems and ionization smoke detectors. Additionally, fixed water-spray systems are provided for the charcoal and HEPA filters in the lower containment air-cleanup units. Thermal detectors are provided for the charcoal filters and HEPA filters. Ionization duct detectors are provided for each lower containment cooling unit and each upper compartment cooling unit. In addition, ionization smoke detectors are provided for the exhaust ducts serving the containment purge and air exhaust systems and the emergency gas treatment system.

TVA stated that a standpipe and hose system is provided in each containment to complement the installed automatic suppression systems. The standpipe systems are normally dry and admit water when a remote control device installed at each hose station is manually operated.

TVA stated that RESs are relied on to separate of cables and associated non-safety circuits of redundant trains. TVA evaluated the combustibility of the RES material in FPR Part VII, Section 2.2, "Non-Combustible Radiant Energy Shields." Section 6.1.2 of this evaluation provides the NRC staff's evaluation of this configuration.

TVA stated that the RCP oil collection system meets the requirements in Section III.O, "Oil collection system for reactor coolant pump," of Appendix R to 10 CFR Part 50 with the exception of a deviation to allow for minor amounts of oil that become entrained in the ventilation air to escape the oil collection system. TVA evaluated the RCP oil collection system in FRP Part VII, Section 2.8, "Reactor Coolant Pump Oil Collection System." See Section 6.1.8 of this evaluation for a detailed evaluation of the deviation.

Based on its review of the information provided by TVA, with the exception of items evaluated elsewhere in this evaluation, the NRC staff concludes that the fire protection features for containment conform to the guidance in Position F.1 of Appendix A, to BTP (APCSB) 9.5-1, and, therefore, are acceptable.

5.2 Control Room Complex

5.2.1 Control Room

Appendix A to BTP (APCSB) 9.5-1 includes guidance for fire protection in the MCR. The MCR is common to both units and contains circuits for safe shutdown for fires outside of the control building. TVA designated the control building, which contains the MCR, an alternative shutdown area. As a result, independent alternative shutdown capability has been provided for this area. Discussion of alternative shutdown is located in FPR Part IV and Section 3.3 of this evaluation. The entire control building is considered a single fire area and is separated from other fire areas (e.g., the auxiliary building, turbine building) by 3-hour fire barriers, as documented in FPR Part VI.

In FPR Part VII, Section 2.6.4, TVA evaluated the affect of nonrated metal hatch covers between the mechanical equipment rooms and the turbine building. Section 6.2.7.4 of this evaluation provides the NRC staff's evaluation of this deviation.

FPR Part VIII summarizes the fire barriers that separate the MCR from the balance of the control building. The MCR is separated from adjacent rooms on the same elevation in the control building by 1-hour rated fire barriers. Doors between the control room and the turbine building and the control room and auxiliary building are 3-hour fire-rated doors. The MCR and the cable spreading room are not separated by a rated fire barrier.

FPR Part VIII describes the use of cables in the MCR. TVA stated that (1) wiring for lighting terminates in the lighting fixtures, (2) instrumentation and control wiring enters through the bottom of cabinets and runs only inside the panels or control boards in which the wires are terminated, and (3) cable are not routed through the control room from one area to another area.

In FPR Part VIII, TVA described manual fire-fighting operations. TVA stated that fire extinguishers are provided in the MCR. Standpipe and hose stations are located in the stairwells at each end of the MCR. TVA also stated that the hose stations have electrically qualified nozzles in alignment with the expected hazards.

TVA stated that ionization smoke detectors are provided in selected cabinets, and additional ionization detectors are installed in the MCR ventilation system. TVA further stated that fire alarms in other parts of the plant, as well as the MCR, alarm and annunciate in a constantly attended location in the MCR.

FPR Part VIII also summarizes smoke control features for the MCR. The MCR ventilation air intakes are provided with remotely controlled dampers to prevent smoke from entering the control room. Manual venting of the control room can be achieved by using portable smoke ejectors available onsite and by opening the doors of the MCR. TVA also stated that breathing apparatuses are available for the control room NRC staff.

TVA evaluated the impact of not providing an automatic suppression system (as required for alternative shutdown locations) in the MCR and corridor in FPR Part VII, Section 2.3. Section 6.1.3 of this evaluation provides the NRC staff's evaluation of this deviation.

In FPR Part VII, Section 4.1, TVA evaluated MCR Doors C49 and C50 for altering the doors by adding signs and security hardware or by repairing onsite damage. Section 6.2.2 of this evaluation provides the NRC staff's evaluation of this configuration.

Based its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, an equivalent level of safety to the separation requirements in Position F.2 of Appendix A to BTP (APCSB) 9.5-1 has been achieved by TVA because of (1) the installed detection and suppression in the cable spreading room, (2) the low combustible loading and installed automatic suppression and detection in adjacent non-MCR control building areas, (3) the provision for alternative shutdown for control building fires through use of the independent ACR complex, and (4) the FSSD evaluation that demonstrates the use of the ACR to achieve post-FSSD, and therefore, is acceptable.

5.2.2 Auxiliary Control Room

TVA designated the control building as an alternative shutdown area. FSSD activities take place outside of the control building for large or damaging fires in the control building. The ACR at WBN provides independent alternative shutdown capability for control building fires. Discussion of alternative shutdown is located in FPR Part IV and Section 3.3 of this evaluation.

TVA stated that the ACR is independent from the control building, which includes the cable spreading room, MCR, and auxiliary instrument room. The ACR is located in the auxiliary building, and is divided into five independent, dedicated rooms. Each room is separated from the others and from the rest of the auxiliary building by at least 2-hour rated fire barriers and from the control building by 3-hour rated fire barriers. The five independent rooms consist of a Train A and a Train B transfer switch room for each unit and a common ACR containing multiple instrumentation and control panels for both units. Ionization smoke detectors and pre-action sprinkler system are provided in each of the five rooms. Standpipe and hose stations are provided for manual fire-fighting activities in the ACR complex from adjacent Rooms 757.0-A2 and -A24.

In FPR Part IV, TVA described the ACR as designed to control the FSSD activities after control has been established at the ACR following MCR abandonment. Systems requiring operator manipulations have the controls located in the ACR along with their associated transfer switches located in the adjacent transfer switch rooms. TVA stated that operators are periodically trained in shutdown procedures from the ACR. TVA further stated that the instruments and controls located in the ACR are separated from, or can be electrically isolated from, the corresponding instrumentation and controls located in the control building.

In FPR Part VII, Section 2.4, TVA evaluated the affect for intervening combustibles, such as insulation on cables in trays and Thermo-Lag® in the ACR. Section 6.1.4 of this evaluation provides the NRC staff's evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the installed fire protection features are consistent with the NRC's current guidance in Position 6.1.6 "Alternative and Dedicated Shutdown Panels," in Revision 2 to RG 1.189, and therefore, are acceptable.

5.3 Cable Spreading Room

The cable spreading room is common to both units and contains circuits for redundant safe shutdown features. TVA designated the control building, which contains the cable spreading room, an alternative shutdown area. As a result, independent alternative shutdown capability has been provided for this area. Discussion of alternative shutdown is located in Part IV of the FPR and Section 3.3 of this evaluation.

TVA stated that the cable spreading room is separated from the adjacent buildings by 3-hour rated barriers. TVA also stated that fire brigade access to the cable spreading room is provided by doors from the turbine building and from enclosed stairways within the control building. TVA stated that portable extinguishers which are located inside and immediately outside the cable spreading room are available. Additionally, standpipe and hose stations are provided from the two stairwells and from the turbine building.

In the FPR Part VIII, TVA summarized the fire protection features for the cable spreading room and stated that these features provide full coverage detection and automatic suppression. The automatic pre-action sprinkler system has a ceiling layer and an intermediate layer of sprinklers under the grating and staggered between the upper level heads. TVA further stated that the installed cables are designed to allow wetting without faulting.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the cable spreading room do not take any exceptions to Position F.3 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.4 Switchgear Rooms

TVA stated that the Trains A and B 6.9 kV and 480 V switchgear rooms are located within the auxiliary building, but separated from each other and from other rooms within the auxiliary building by 2-hour fire rated barriers and from the control building by 3-hour fire rated barriers. Each room is provided with a full area coverage automatic pre-action sprinkler system that is actuated by a cross-zoned area-wide ionization smoke detection system. Water spray shields have been installed to protect safety related electrical equipment against the effects of inadvertent or advertent actuation of the automatic suppression system. Additionally, standpipe and hose stations are provided in each of the switchgear rooms.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the essential switchgear rooms provide an equivalent level of fire safety to Position F.5 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.5 Battery Rooms

TVA stated in FPR Part VIII, that the required Vital Battery Rooms I through IV are separated from all other plant areas by 3-hour fire rated barriers. The Fifth Vital Battery Room is a spare that can be used for any of the other four vital batteries. TVA further stated that the Fifth Vital Battery Room is separated from other plant areas by 2-hour fire rated barriers that exceed the hazards to which they could be exposed.

TVA also stated that ceiling vents are provided for each battery room with a direct exhaust to outside the building to maintain the concentration of hydrogen below 2 percent by volume within the battery rooms. Additional details of these exhaust systems are available in WBN Unit 2 FSAR Section 9.4.3.2.5,"Auxiliary Board Rooms Air-Conditioning Systems."

TVA provided a summary of the fire protection features for the battery rooms in FPR Part VIII. TVA stated that full coverage automatic smoke detection and manually actuated sprinkler system are provided for Vital Battery Rooms I to IV. Smoke detection and an automatic pre-action sprinkler system are provided for the Fifth Vital Battery Room. With regard to manual fire-fighting, TVA stated that hose stations and portable fire extinguishers are available for fire brigade use.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the battery rooms do not take exceptions to Position F.7 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.6 Turbine Lubrication and Control Oil Storage and Use Areas

TVA stated in FPR Part VI that a fire in the turbine building would not impact equipment required to achieve safe shutdown, and that Train A and B systems and components would be utilized without mitigating actions. TVA further stated that cable tray penetrations through the 3-hour fire rated fire barrier separating the turbine building from the control building are sealed with 3-hour fire-rated penetration seals and are provided with automatic water curtain protection on the turbine building side. TVA stated in FPR Part VIII that turbine building oil hazards are protected by fixed water spray systems. Additionally, standpipe and hose stations are provided on each elevation of the turbine building.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the turbine building provide an equivalent level of safety as the guidelines in Position F.8 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.7 Diesel Generator Areas

In the FPR Part VIII, TVA stated that the diesel generator building is remotely located and is not adjacent to any other safety related building or structure, and that each diesel generator and its associated equipment are separated from each other by 3-hour fire barriers.

TVA described the automatic fire suppression systems installed in these areas as follows. Each diesel generator area is provided with full coverage detection that alarms and annunciates in the control room and alarms locally. Automatic, total flooding CO2 suppression systems protect each diesel generator, the associated day tanks, and the electrical board room. TVA also stated that the diesel generator building pipe gallery and corridor are protected by a pre-action sprinkler system. For manual suppression, TVA stated that standpipes and hose stations are available on both elevations of the diesel generator building, with back-up from hydrants in the yard.

TVA stated that the two 550-gallon day tanks are located in the same room as the associated tandem diesel generator.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the diesel generator areas do not take any exceptions to Position F.9 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.8 Diesel Generator Fuel Oil Storage Areas

In FPR Part VIII, TVA stated that the above ground diesel fuel oil storage tanks are located more than 50 feet from any safety related building or structure, and that they are located within a diked area sized to contain leaks or spills of fuel oil.

TVA further stated that the 7-day fuel oil storage tanks for each diesel generator are buried under the floor of the diesel generator building. The only portions of the tanks that are not buried are the manway access openings to each tank within the diesel rooms and in the common corridor outside the diesel rooms. TVA evaluated the impact of these non-rated manway access openings in the FPR Part VII, Section 4.4, "Fire Barriers between DG [Diesel Generator] Storage Tank and DG Corridor." Section 6.2.9 of this evaluation provides the NRC staff evaluation of this deviation. TVA evaluated the impact of an untested penetration assembly in the fire barrier between the fuel oil transfer pump room and the diesel generator corridor in the FPR Part VII, Section 4.6, "Fire Barriers between Fuel Oil Transfer Pump Room and Diesel Generator Building Corridor." Section 6.2.5 of this evaluation provides the NRC staff's evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the fire protection features for the diesel fuel oil storage areas are consistent with Position F.10 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.9 Safety-Related Pump Areas

5.9.1 CCS Pump Area

As described in TVA's response dated May 26, 2011 (ADAMS Accession No. ML111520119), to RAI FPR VII-3, the CCS pumps are located in the same fire area in the auxiliary building on elevation 713.0 feet. The two Train A CCS pumps are separated from the two Train B pumps, and the spare, by a partial height fire barrier.

TVA evaluated the partial height fire barrier between the CCS pumps and the ensuing redundant train separation issues in FPR Part VII, Section 2.5. Section 6.1.5 of this evaluation provides the NRC staff's evaluation of this configuration.

TVA stated in FPR Part VII, that the area containing the CCS pumps is provided with automatic pre-action sprinkler system protection at the ceiling and under the grated mezzanine over the CCS pumps as well as full coverage automatic smoke detection. Further, in FPR Part VI, TVA stated that hose stations are available to support manual fire-fighting.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the fire protection features for the CCS pumps do not take any exceptions to Position F.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.9.2 Charging Pumps

As described in the FPR Part VI, each charging pump is located in its own 2-hour fire-rated compartment. TVA stated that the pump rooms and the corridor outside these rooms are protected by full coverage detection and an automatic pre-action sprinkler system. However, detection and suppression is not extended into the entrance labyrinth of the charging pump rooms. Further, TVA stated that hose stations are located in the corridor leading to these rooms and are available to support manual fire-fighting inside the pump rooms.

TVA evaluated the impact of the lack of total area suppression and detection in the FPR Part VII, Section 3.1, "Lack of Total Area Suppression and Detection." Section 6.1.7 of this evaluation provides the NRC staff evaluation of this deviation.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the fire protection features for the charging pumps provide an equivalent level of safety to Position F.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.9.3 AFW Pumps

As described in the FPR Part VI, the two turbine-driven AFW pumps (one for each unit) are located in the auxiliary building on elevation 692.0 feet. Each pump is located in its own 2-hour fire rated fire compartment. TVA stated that each pump room is provided with full coverage automatic detection and an automatic pre-action sprinkler system. Further, TVA stated that hose stations are located in the corridor leading to these rooms and are available to support manual fire-fighting inside the pump rooms.

As described in TVA's response dated May 26, 2011 (ADAMS Accession No. ML111520119), to NRC question RAI FPR VII-3, the motor-driven AFW pumps (two per Unit) are located on opposite ends of the auxiliary building on elevation 713.0 feet. TVA stated that there is approximately 126 feet separating the Unit 1 and Unit 2 AFW pumps. TVA further stated that the area in which these pumps are located is protected by an automatic pre-action sprinkler system, and that automatic fire detection is provided throughout the area. TVA stated in FPR Part VI that hose stations are available in the area to support manual fire-fighting operations.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features provided for the motor-and turbine-driven AFW pumps provide an equivalent level of fire safety to Position F.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.9.4 RHR Pumps

As described in the FPR Part VI, each RHR pump is located in its own 2-hour fire rated fire compartment. Each RHR pump room is a separate fire area and none of the rooms contain redundant trains of equipment or cables. TVA stated that the corridor outside these rooms has full coverage fire detection installed. In each pump room, fire detection is installed, except in the entrance labyrinths. TVA stated that the combustible loading in these rooms is insignificant, consisting mainly of the lube oil associated with the pump and valve. TVA stated that for each fire area, the capability to achieve safe shutdown has been demonstrated through analysis. Therefore, a fire in any of these fire areas will not endanger other safety related equipment required for safe plant shutdown. Further, TVA stated that hose stations are located in the corridor leading to these rooms and are available to support manual fire-fighting inside the individual RHR pump rooms.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features for the RHR pumps provide an equivalent level of fire safety to Position F.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.9.5 ERCW Pumps

As described in FPR Part VI, the redundant ERCW pumps are separated by 3-hour fire rated barriers. These pumps are also separated from the traveling screen pumps by 3-hour barriers. However, these barriers have open scuppers at the base of the wall of the ERCW pump rooms.

TVA stated in FPR Part VI that heat detectors are installed over the ERCW pumps and that no redundant FSSD cables or equipment are installed in these areas. Further, TVA stated that manual fire suppression capability is available through use of hose stations installed in the ERCW strainer room and the screen wash pump room.

TVA evaluated the impact of the open scuppers in the fire barriers that separate the pumps from the traveling screens in the FPR Part VII, Section 2.6.2, "Justification for Scupper Openings." Section 6.2.7.2 of this evaluation provides the NRC staff evaluation of this configuration.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the fire protection features for the ERCW pumps provide an equivalent level of fire safety to Position F.11 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.10 Other Plant Areas

5.10.1 Areas without Deviations or Evaluations

The NRC staff reviewed TVA's compliance with the following positions of Appendix A to BTP (APCSB) 9.5-1, as documented in FPR Part VIII:

- Position F.4 –"Plant Computer Room"
- Position F.6 –"Remote Safety-Related Panels"
- Position F.14 –"Radwaste Building"
- Position F.15 –"Decontamination Areas"
- Position F.16 –"Safety-Related Water Tanks" Position
- F.17 –"Cooling Towers"
- Position F.18 –"Miscellaneous Areas"

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire protection features provided in these areas provides an equivalent level of fire safety as the guidance in these sections of Appendix A to BTP (APCSB) 9.5-1, and, therefore, are acceptable.

5.10.2 Areas with Deviations or Evaluations

The NRC staff reviewed TVA's compliance with the following positions of Appendix A to BTP (APCSB) 9.5-1, as documented in FPR Part VIII:

- Position F.12 –"New Fuel Area"
- Position F.13 –"Spent Fuel Pool Area"

TVA evaluated the impact of the lack of installed fire detection in these areas in FPR Part VII, Section 4.5. Section 6.2.1 of this evaluation provides the NRC staff's evaluation of this configuration.

Based on its review of the information submitted by TVA, the NRC staff concludes that, with the exception of items evaluated elsewhere in this evaluation, the fire protection features for these areas provide an equivalent level of fire safety to Positions F.12 and F.13 of Appendix A to BTP (APCSB) 9.5-1 and, therefore, are acceptable.

5.11 Specific Hazards

5.11.1 Hydrogen Piping

TVA stated in the FPR that a 1-inch seismically-designed hydrogen line is routed through the auxiliary building on elevation 713.0 feet to each unit's VCT. Two isolation valves are installed in the hydrogen supply line outside the auxiliary building. These valves close automatically when the downstream flow rate reaches 50 standard cubic feet per minute (scfm). TVA stated that any hydrogen leakage less than 50 scfm will be diffused and carried away by the auxiliary building ventilation system, keeping the hydrogen concentration in any given area below the lower explosive limit.

Based on its review of the information submitted by TVA, the NRC staff concludes that the hydrogen supply piping in the auxiliary building does not take any exceptions to Position D.2.b of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

5.11.2 Transformers Installed Inside Buildings

TVA stated that transformers located inside of buildings are either dry type or medium voltage transformers that contain "high fire point," transformer liquid. The use of dry type transformers is consistent with the NRC guidance in Appendix A of BTP 9.5-1, Element D.1.g, but the use of transformers with "high fire point" silicone fluid is not included as part of the guidance.

In TVA's response dated August 5, 2011 (ADAMS Accession No. ML11224A052), to RAI VIII-21, TVA provided its justification for the use of the "high fire point" silicone fluid in lieu of the non-combustible liquid described in Appendix A to BTP 9.5-1. TVA stated that the non-combustible transformer liquids contained PCB fluids. PCB fluids are considered non-combustible, but constitute an occupational health and safety, as well as environmental, concern if leaked or spilled. Therefore, TVA decided to remove PCB fluids from the plant. Although the "high fire point" liquid is considered combustible, it is not considered flammable in accordance with the definition of flammable and combustible provided by NFPA 30-1973, "Flammable and Combustible Liquids Code."

TVA stated that all areas where these transformers are located have sprinkler protection. Based on the vendor information provided by TVA in Attachment 4 of its letter dated September 30, 2011 (ADAMS Accession No. ML13060A225), sprinkler systems are effective at extinguishing silicone fluid fires. TVA also considered dikes to contain the volume of the silicone fluid if it were to leak from the transformers.

In its response dated September 30, 2011, to RAI VIII-21.1, TVA provided additional information regarding the installation of transformers containing "high fire point" silicone fluid. The NRC staff questioned the location of these transformers in plant areas that constitute buffer zones between analysis volumes, since the transformers were not described as being located in the buffer zones. TVA confirmed, in its RAI response, that the transformers are not located in buffer zones for large fire areas except for in the electrical equipment room in the IPS.

The transformers in the electrical equipment room in the IPS have dikes, are protected with automatic fire suppression systems, and there is 20 feet of separation between the transformers and the redundant FSSD train. TVA stated that the 20 feet of separation has intervening combustibles, but the combustibles are not continuous. Therefore, in the event that a transformer fire was to occur in this area, automatic suppression and spatial separation is available to assure that safe shutdown capability is assured.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA's use of dry type transformers in plant areas is consistent with Appendix A of BTP 9.5-1, Element D.1.g, and, therefore, is acceptable. The use of "high fire point" silicone fluid in transformers in plant areas is acceptable where the transformers are installed in areas with automatic sprinkler systems and spatial separation, either buffer zones or 20 feet without continuous intervening combustibles, and where transformers have dikes large enough to contain the volume of the transformer fluid.

6.0 DEVIATIONS AND EVALUATIONS

In FPR Part VII, TVA documented deviations from WBN commitments against applicable NRC regulatory criteria and guidance documents and presented engineering evaluations of the adequacy of specific fire protection features.

6.1 Deviations and Evaluations Related to Criteria in Appendix R to 10 CFR Part 50

6.1.1 Deviation – Required Instrumentation for Alternative Shutdown

TVA committed to maintain safe shutdown capability during and after a fire in accordance with Section III.L of Appendix R to 10 CFR Part 50. Section III.L.2.d of Appendix R to 10 CFR Part 50 states that the process monitoring function for alternative shutdown be capable of providing direct readings of the process variables necessary to perform and control a plant cooldown.

Contrary to Section III.L.2.d of Appendix R to 10 CFR Part 50, TVA has not provided instrumentation in the ACR for (1) tank level indication for the CST or the RWST, (2) wide-range SG level indication, and (3) cold-leg temperature indication. TVA evaluated these deviations in FPR Part VII, Section 2.1. TVA's justification for omitting this instrumentation is given below.

The CST level indication is not considered essential in the ACR because automatic switchover of the AFW pump suction from the CST to the ERCW header is independent of the control building, and therefore would be available when control is established in the ACR.

The RWST level indication is not considered essential in the ACR because the RWST contains almost 20 times the inventory required for cold shutdown. Because the RWST is primarily used as makeup water for contraction resulting from cooldown over a period of hours, the excess inventory in the RWST is considered sufficient without level indication in the ACR.

Wide-range SG level indication is not provided in the ACR. Instead, the narrow-range SG level and AFW flow indication to each SG are provided in the ACR and are sufficient for use in safe shutdown procedures whenever the ACR is utilized. This instrumentation also provides input to the automatic control utilized to maintain SG level during plant shutdown from the ACR. Although wide-range instrumentation is available in the MCR, no automatic control or safety system inputs are derived from this instrumentation. Therefore, the AFW flow indication is sufficient for the operator to confirm that adequate post-trip SG inventory is available in the event that SG level falls below the range of the narrow range indicators that are located in the ACR.

Cold leg temperature indication is not provided in the ACR. Cold leg temperature (TC), is used for monitoring natural circulation. Rather than using TC, TVA monitors natural circulation by inferring TSAT, the saturation temperature corresponding to the secondary-side SG pressure. In the natural circulation mode of operation, the difference between the hot-leg and cold-leg temperature (TH-TC) provides an effective indication of when natural circulation is established and whether it is being maintained. TSAT will be used to monitor natural circulation in the reactor coolant loop in the operating range from full power to the hot standby condition. To demonstrate that TSAT will accurately monitor natural circulation in the operating range from hot standby to cold shutdown, TVA analyzed the correlation between TSAT and TC while a reactor was brought to cold-shutdown condition.

TVA stated that the Westinghouse Owners Group document "Emergency Response Guidelines, Generic Issue on Natural Circulation," Revision 1, provides specific guidelines on how an operator can verify that natural circulation has been established without TC being available. The Westinghouse Owners Group recommends the use of the following criteria for verifying natural circulation: (1) RCS is subcooling (conversion of pressurizer pressure to TSAT and subtracting TH); (2) TH is stable or decreasing, and (3) SG pressure is stable or decreasing. The instrumentation needed to use these methods of verifying natural circulation is available to the operator in the ACR. Therefore, the installed indication is sufficient to compensate for the lack of TC indication in the ACR.

Based on its review of the information submitted by TVA, the NRC staff concludes that not providing wide-range SG level, CST and RWST tank water level indication, and cold-leg temperature indication in the ACR, are acceptable deviations from Section III.L.2.d of Appendix R to 10 CFR Part 50.

6.1.2 Deviation – Noncombustible Radiant Energy Heat Shields

TVA committed to maintain safe shutdown capability during and after a fire in accordance with Section III.G of Appendix R to 10 CFR Part 50. Section III.G.2.f of Appendix R to 10 CFR Part 50 states that inside non-inerted containments, separation of cables and equipment and associated non-safety circuits of redundant trains by a noncombustible RES is an acceptable method of ensuring that a redundant train of equipment and circuits are protected from a fire.

The acceptance criteria included in previous revisions to NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 9, "Auxiliary Systems," Section 9.5.1.1, "Fire Protection Program," as BTP APCSB 9.5-1 (BTP Chemical Engineering Branch (CMEB) 9.5-1 at the time of publication of GL 86-10) have been removed and have been incorporated in Revision 2 of RG 1.189. Section 6.1.1.1, "Containment Electrical Separation," to RG 1.189 states the following:

> Inside noninerted containments, one of the fire protection means specified in Regulatory Position 5.3.1.1, or one of the following, should be provided:
>
> a. separation of cables and equipment and associated nonsafety circuits of redundant trains by a horizontal distance of more than 6.1 m (20 feet) with no intervening combustibles or fire hazards,
>
> b. installation of fire detectors and an automatic fire suppression system in the fire area, or
>
> c. separation of cables and equipment and associated nonsafety circuits of redundant trains by a noncombustible RES having a minimum fire rating of 30 minutes, as demonstrated by testing or analysis.

Section 3.7.1, to GL 86-10 states the following:

> The guidelines in BTP CMEB 9.5-1, Section C.7.a.(1)b. indicate that these shields should have a fire rating of 1/2 hour. In our opinion any material with a 1/2 hour fire rating should be capable of performing the required function.

TVA evaluated this deviation in FPR Part VII, Section 2.2. The RESs installed inside the reactor buildings at WBN are Minnesota Mining and Manufacturing (3M) M20A in the annulus, and M20C in the Unit 1 primary containment. TVA stated that site calculations EPM-BFS-041895 and EPM-BFS-053195 provide the design basis for the number of layers of M20A and M20C required to provide approximately 1/2 hour RESs for electrical raceways containing circuits required for FSSD. These calculations were based on fire tests performed by 3M to UL Subject 1724, "Fire Tests for Electrical Circuit Protective Systems." The fire exposure used in the tests is the standard time-temperature curve from ASTM E119.

TVA had a series of fire resistance tests performed on the material at Omega Point Laboratories for combustibility of the installed materials. The 3M M20A and M20C did not meet the criteria for non-combustibility per ASTM E136, "Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750° C." Additional fire tests to the criteria in ASTM E1354, "Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter," were performed with various RES materials. The results indicated that the peak heat release rate (HRR) and the total heat release rate (THR) for the 3M M20A and M20C was lower than that of marinite board. Since marinite board is accepted in GL 86-10 as an acceptable RES material, and the 3M materials used at WBN have lower HRR and THR than marinite board, the 3M materials are also considered sufficiently noncombustible for the use as RES.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire rating and combustibility of the 3M M20A in the annulus and 3M M20C in the WBN Unit 1 primary containment provide an equivalent level of fire safety to that required by Section III.G.2.f of Appendix R and, therefore, are acceptable.

6.1.3 Deviation – Lack of Automatic Fire Suppression in Alternative Shutdown Locations

TVA committed to maintain safe shutdown capability during and after a fire in accordance with Section III.G of Appendix R to 10 CFR Part 50. Section III.G.3 of Appendix R to 10 CFR Part 50 states that fire detection and a fixed fire suppression system shall be installed in the areas, rooms, or zones requiring alternative or dedicated shutdown capability.

TVA requested a deviation from this Appendix R requirement for a number of control building rooms that lack fixed fire suppression, and some rooms that also lack fire detection.

The control building is separated from the ACR and adjacent plant areas by equivalent 3-hour fire rated barriers except for the equipment hatch in the ceiling separating the control building from the turbine building. The justification for the hatch opening through the ceilings of Rooms 692.0-C1 and 692.0-C10 to the turbine building is evaluated in Section 6.2.7.4 of this evaluation. The turbine building is separated from the ACR and adjacent plant areas by equivalent 3-hour fire rated barriers. This separation provides assurance that safe shutdown capability is assured for a fire in the control building.

All the control building rooms that lack fixed fire suppression have limited ignition sources and low or insignificant combustible loading. In addition, all of the rooms have standpipes and hose stations available for manual fire-fighting. Only a few rooms lack full area detection. These rooms are stairwells, shower rooms, the telephone room, and the space above the living area on the 755.0 foot elevation. Frequent use of the stairwells would lead to discovery of a fire in its early stages and would also reduce the likelihood that combustibles could accumulate there. The other rooms all are described as having negligible combustible loading.

Based on its review of the information submitted by TVA, the NRC staff concludes that the lack of fire detection and fixed suppression in the control building areas identified above is an acceptable deviation from the requirements of Section III.G.3 of Appendix R to 10 CFR Part 50, because all rooms that lack fixed suppression have low levels of combustibles and available manual suppression, and the rooms that also do not have fire detection have negligible fire loading.

6.1.4 Deviation – Intervening Combustibles

TVA committed to maintain safe shutdown capability during and after a fire in accordance with Section III.G of Appendix R to 10 CFR Part 50. Section III.G.2.b of Appendix R to 10 CFR Part 50 states that separation of redundant trains of safe-shutdown cables and equipment by a horizontal distance of more than 20 feet with no intervening combustibles. In addition, fire detection and an automatic fire suppression system shall be installed in the area.

In FPR Part VII, Section 2.4, TVA requested a deviation from compliance with Section III.G of Appendix R to 10 CFR Part 50 for 20 feet horizontal distance with no intervening combustibles for safe shutdown components and cables in the auxiliary building and the IPS electrical equipment room. WBN stated that safe shutdown components in the auxiliary building and IPS electric equipment room are in compliance with Section III.G.2.b of Appendix R to 10 CFR Part 50 requirements except that intervening combustibles are located between the redundant components.

The intervening combustibles in the auxiliary building are mainly in the form of insulation on cables in open ladder type cable trays and Thermo-Lag fire barrier material. The remaining in situ combustible loading consists of lubricating oil in pumps, motors, and valves; transformer silicon liquid; and plastics in electrical panels, junction boxes, etc. The intervening combustibles in the IPS electric equipment room are mainly in the form of insulation on cables in open ladder type cable trays and transformer silicone liquid. The remaining in situ combustible loading consists of lubricating oil in small pumps, plastics associated with electrical panels, junction boxes, etc. Discussion of the nature of the transformer silicon liquid can be found in Section 5.11.2 of this evaluation.

The presence of these intervening combustibles is a concern because they add to a fire's intensity at the ceiling and they could serve as a path for fire propagation between the redundant safe-shutdown trains.

For intervening combustibles in the auxiliary building, TVA stated that existing sprinkler heads, which are capable of fully developing spray patterns at the ceiling, provide acceptable floor coverage if there are no intermediate obstructions in their patterns, which are greater than 48 inches wide. Additional intermediate sprinklers are provided for 48 inch wide obstructions and for combinations of obstructions that, when overlapped, constitute a 48 inch wide obstruction, that overlap or combinations of obstructions have less than a 4 inch flue space between them when viewed from immediately below. No combination of obstructions may traverse the 4 inch flue space and block more than 2 feet of any 8 feet of flue space. To mitigate the effects of an exposure fire from transient combustibles at the floor level, TVA stated that floor level sprinkler coverage is provided under intermediate obstructions for up to a 30 foot wide path where spatially separated redundant FSSD components exist.

TVA stated that for intervening combustibles in the IPS electrical equipment room, sprinkler protection has been provided at the ceiling level. Due to the presence of obstructions such as HVAC ducts, cable trays, pipes, and supports, these systems have been upgraded. Sprinkler heads were added to provide full coverage at the ceiling level and to compensate for large intermediate level obstructions. To mitigate the effects of an exposure fire from transient combustibles at the floor level, TVA provided floor level sprinkler coverage under intermediate obstructions for up to a 30-foot wide path for spatially separated redundant FSSD components.

TVA concluded that, if a fire were to occur, these sprinkler systems would develop effective spray patterns at the ceiling, and the water would cascade down through the cable trays in the intervening spaces. The cooling effect of these sprinklers, once actuated, would help cool the layer of hot gas at the ceiling, prevent the formation of a high temperature plume, and cool the room. The sprinklers under the intermediate level obstructions would actuate to ensure that floor level coverage is provided under the obstructions. In addition, the coverage provided by the ceiling sprinklers would produce sufficient cooling to reduce the likelihood that fire will propagate across the intervening space between the redundant trains.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the arrangement and nature of the combustibles, and the upgraded suppression systems, the presence of intervening combustibles as fire hazards between redundant trains of safe shutdown functions is an acceptable deviation from the requirements of Section III.G.2.b of Appendix R to 10 CFR Part 50.

6.1.5 Deviation – Partial Fire Wall between CCS Pumps

TVA committed to maintain safe shutdown capability during and after a fire in accordance with Section III.G of Appendix R to 10 CFR Part 50. Section III.G.2.b of Appendix R to 10 CFR Part 50 states that separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area. Section III.G.2.c states that enclosure of cables and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.

In FPR Part VII, Section 2.5, TVA requested a deviation from these Appendix R requirements for redundant CCS pumps that are protected by fire detectors and an automatic fire suppression system, but are separated by a partial height and width noncombustible wall.

The five CCS pumps are located in Fire Area 8, Room 713.0-A1, in subsections 713.0-A1A1, -A1A2 and -A1A3, on elevation 713.0 feet of the auxiliary building. The two Train B pumps are separated from both Train A pumps and the spare pump by a noncombustible wall which extends 3 feet above the highest point of the pumps. A ceiling-level pre-action sprinkler system is provided for cable tray and general area coverage. Automatic sprinkler coverage has also been provided under the pipe-break barrier for the Unit 1 motor-driven AFW pumps and under the mezzanine for all five CCS pumps. Cross-zoned ionization smoke detectors are provided to actuate the pre-action suppression systems and give early warning of a fire.

The combustibles in Room 713.0-A1 consist of lube oil in the pumps, motors, and valves; plastics associated with the electrical panels, boxes and lights, insulation on cables routed in cable trays; and anticipated amounts of radwaste trash and laundry. The fire severity for this room is classified as moderately severe. However, TVA stated that approximately 95 percent of the in situ combustible loading in this area is due to the insulation on cables routed in cable trays and the Thermo-Lag fire barrier material. The majority of the remaining combustible loading in the immediate area of the CCS pumps is due to the approximately 6 gallons of lube oil associated with each CCS pump and approximately 45 gallons of lube oil associated with each of the two Unit 1 AFW pumps. The cables are protected electrically with appropriately sized circuit protective devices (breakers and fuses) that will actuate on electrical faults prior to the jacket material of faulted cables reaching their auto-ignition temperature. A fire due to transient combustibles located near the edge of the partial height fire barriers would not pose a threat to more than one CCS pump due to the lack of combustibles. Additionally, raceways containing the redundant cables for the CCS pumps are separated by 20 feet or more or by noncombustible barriers.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire detection system and automatic sprinkler system would detect and suppress a fire prior to becoming a threat to the redundant pumps on the other side of the noncombustible barrier. Until the fire is suppressed, the noncombustible barrier will shield the pumps from radiant heat on one side and from fire on the other. Therefore, because of the noncombustible nature of the barrier, the installed fire detectors and automatic fire suppression systems, and redundant cable separation, the partial height fire wall is an acceptable deviation from the technical requirements of Sections III.G.2.b of Appendix R to 10 CFR Part 50.

6.1.6 Deviation – Emergency Lighting

TVA committed to provide emergency lighting to assure safe shutdown capability is maintained during and after a fire in accordance with Section III.J of Appendix R to 10 CFR Part 50. Section III.J of Appendix R to 10 CFR Part 50 states that emergency lighting units with at least an 8 hour battery power supply be provided in all areas needed for operation of safe-shutdown equipment and for necessary access and egress routes.

In FPR Part VII, Section 2.7, TVA requested a deviation from this emergency lighting requirement in each containment, the turbine building, and the yard. Dedicated and maintained hand-held portable lanterns are provided in lieu of installed battery pack lighting units in both containments. Emergency diesel generator backed standby lighting is installed and maintained for the turbine building. Security diesel generator backed standby lighting is installed and maintained for the yard. Additionally, hand-held portable lanterns are available to supplement yard and turbine building diesel backed lighting systems to provide additional task lighting capability.

The hand-held portable lanterns used for this purpose are rechargeable, industrial duty, 12 VDC devices. They can continuously operate for up to 9 hours per charge. They are stored in cages and placed on electrical charge from the plant's 120 VAC lighting system. The lights are inventoried to ensure they are in their assigned location, operated to ensure they will illuminate, and are verified to be on charge every 13 weeks.

Based on its review of the information submitted by TVA, the NRC staff concludes that the use of installed standby lighting and hand-held portable lighting units for the yard and turbine building is an acceptable deviation from the lighting criteria required by Section III.J, of Appendix R to 10 CFR Part 50, and, therefore, is acceptable.

OMAs requiring entry into primary containment would only result from fire damage to the RHR isolation valves or cables near the valves which are located inside lower containment. The OMAs to align the RHR isolation valves may be performed anytime within 4 hours after reactor trip. This allows ample time to extinguish the fire, obtain the portable lanterns, and operate the valves. As described above, WBN has dedicated hand-held portable lighting units for use in supporting manual fire-fighting and safe shutdown OMAs for fires in the lower containment.

A fire affecting the RHR isolation valves could damage lighting circuits in the immediate vicinity, but would not be expected to disable all lower containment lighting, since different circuits are used at each elevation. Additionally, two standby lighting circuits, with fixtures strategically located throughout lower containment, provide lighting in case of fire damage to the normal lighting cabinet.

TVA's concerns regarding the installation of 8-hour emergency lighting units inside containment include the reduced life of the batteries in the high temperature and humidity environment experienced inside the primary containment. Also, ALARA concerns would limit testing and maintenance to reactor outages, since access into the primary containment during plant operations is restricted.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the complications of testing and maintaining 8-hour fixed emergency lighting units, and TVA's design description of the installed lighting in the lower containment complemented by the dedicated hand-held portable lighting units, the installation of 8-hour emergency lighting units is unnecessary to provide access and egress to the manual action sites and perform safe shutdown actions in primary containment. Therefore, the use of installed lighting and hand-held portable lighting units for this area is an acceptable deviation from the lighting criteria required by Section III.J of Appendix R to 10 CFR Part 50.

6.1.7 Evaluation – Lack of Total Area Suppression and Detection

TVA committed to meet Section III.G.2 of Appendix R to 10 CFR Part 50 for hot shutdown capability, which states that when redundant trains of cables or equipment necessary for post-FSSD are installed in the same fire area, fire detectors and automatic fire suppression must be installed, unless one train is protected by a 3-hour rated fire barrier. Position 5 of the Attachment to GL 86-10 states that to meet the requirements of Section III.G.2 of Appendix R to 10 CFR Part 50, less than full area coverage may be adequate to comply with the regulation if the suppression and detection installed is sufficient to protect against the hazards of the fire area.

In FPR Part VII, Section 3.1, TVA evaluated portions of fire areas that contain both trains of safe shutdown success paths, but do not have full coverage fire detection and suppression installed. The WBN plant has some fire areas that include multiple subdivisions, called rooms.

These rooms may not be separated from the other rooms within the fire area by rated fire barriers.

The NRC staff notes that for fire areas composed of multiple rooms, the rooms which contain redundant safe shutdown equipment have either 3-hour rated barriers to protect one train of the safe shutdown equipment, or the rooms are equipped with fire detection and automatic suppression, and have some spatial separation between trains (see Section 3.2.1 of this evaluation). Therefore, these rooms are not considered to be credible exposure hazards to the other rooms in the fire area that have redundant safe shutdown equipment.

Some of the rooms contain safe shutdown equipment, but there is not redundant safe shutdown equipment required for hot shutdown in the room. In other cases, the safe shutdown equipment is needed for cold shutdown, or for alternative shutdown. In still other cases, the safe shutdown equipment is not used to provide for plant safe shutdown for a fire in the room; that is, it is relied upon for a fire elsewhere in the plant. In any of these cases, safe shutdown equipment is available outside of the room if there is a fire in the room and any exposure hazard in the room to another room would be mitigated by the protection in the other room.

Based on the information provided by TVA, there are rooms that lack full area fire detection and suppression that do not contain redundant safe shutdown equipment needed for hot shutdown and do not constitute exposure hazards to other rooms within the fire area. The NRC staff has reviewed this information and concludes that this is acceptable.

The descriptions in the evaluations state that the plant provided only one train of FSSD equipment and cables in Centrifugal Charging Pump (CCP) Rooms 1B-B (Room 692.0-A10; Fire Area 6), 2A-A (Room 692.0-A22; Fire Area 67), and 2B-B (Room 692.0-A23; Fire Area 68). However, Fire Areas 6, 67, and 68 consist solely of the single CCP room. Because these rooms do not contain redundant trains of equipment or cables, the NRC staff did not review these evaluations.

Rooms that contain redundant cables or equipment necessary for post-FSSD

480 V Board Rooms 1B (Room 772.0-A2; Fire Area 33) and 2B (Room 772.0-A15; Fire Area 45)

In FPR Part VII Section 3.1.8, TVA stated that in 480 V Board Rooms 1B (Room 772.0-A2; Fire Area 33) and 2B (Room 772.0-A15; Fire Area 45), pre-action sprinkler systems are provided throughout both rooms except for the portion of each room that contains one set of vital battery inverters and chargers. Additionally, ionization detection is installed throughout both rooms. TVA further stated that the redundant inverters and chargers and associated cables are separated by a minimum of 42 feet and are located at opposite ends of each room. Additionally, TVA stated that other redundant components in the rooms are located within the suppressed area of each room and are separated in accordance with Section III.G.2 of Appendix R to 10 CFR Part 50. A fire in the unsprinklered locations in these rooms would be detected by the installed fire detection systems before propagating significantly. If the fire propagated rapidly before the fire brigade arrived, individual sprinklers in the protected portions of the rooms would operate to limit the spread of fire and to protect the redundant systems until the fire was controlled and suppressed by the plant fire brigade.

Based on its review of the information submitted by TVA, the NRC staff concludes that the partial coverage of the automatic suppression systems in these rooms is sufficient to protect against the fire hazards in these areas and that this level of protection, including the separation between trains, provides an equivalent level of fire safety to that required by Sections III.G.2.b and III.G.2.c of Appendix R to 10 CFR Part 50 and, therefore, is acceptable.

6.1.8 Evaluation – Reactor Coolant Pump Oil Collection System

TVA has committed to meet Section III.O of Appendix R to 10 CFR Part 50. This section states, in part, that RCPs be equipped with an oil collection system if the containment is not inerted during normal operation and that the system be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the RCP lube oil system.

In FPR Part VII, Section 2.8, TVA stated that the RCP oil collection system must function in an area with significant ventilation airflows from both the control rod drive mechanism cooling units and the RCP motor itself. A minor leak in the lubrication system that causes oil to drip in an area where the ventilation airflow is strong can result in the oil becoming entrained in ventilation air, which in turn could prevent the leak from ever entering the collection system. The need for ventilation around the RCP dictates that some ventilation flow areas must be present in areas around the lube oil system and the oil collection system. In designing the oil collection system, it is not feasible in all instances to prevent minor amounts of oil from becoming entrained in the ventilation air and escaping the collection system. This oil may become a thin film on the piping mirror insulation and supports in the vicinity of the RCPs.

TVA described the RCP oil collection systems in a letter dated May 26, 1995 (ADAMS Accession No. ML073230888). TVA used the following design criteria as the basis for the oil collection systems.

The oil collection system on each RCP collects oil from all potential leakage locations, including the RCP oil lift pump, system piping, overflow lines, the lube oil cooler, oil fill and drain lines, flanged connections on the oil lines, and the lube oil reservoirs. Each RCP oil collection system consists of spray shields/deflectors, a collection basin, a lift pump collection tray, a lower bearing collection tray and drain, drain piping, and a closed, vented container (reactor building floor and equipment drain sump).

The drain piping from each RCP's oil collection basin is directed to a drain header. The drain header runs through the shield wall and into the raceway area inside primary containment and runs through the floor into the 1600 gallon capacity sump. As required by Appendix R, the sump is a closed container and is equipped with a flame arrester on the vent line. Each unit's sump has sufficient capacity to hold the entire RCP oil inventory of all four RCPs.

TVA stated that up to 14 gallons of oil could collect in the lower motor support housing before beginning to drain to the collection system. The RCPs are equipped with control loop level indication that would initiate an alarm in the MCR if 2 or more gallons of lube oil are lost from the RCP. Collection of oil within the lower motor support housing is acceptable since the oil, and possible fire, would be contained within the RCP and would not impact surrounding equipment such that safe shutdown could be affected. In addition, the RCP is equipped with a water-based fire suppression system such that a fire at the RCP would have automatic suppression available.

The RCP pumps, lubricating oil systems, oil spray shields, oil collection basins, drain piping, and containment sumps are designed to seismic Category I requirements so as not to fail during a safe-shutdown earthquake.

Each of the four RCPs is protected by a fixed fire suppression and detection system. A heat collection hood is installed directly above the RCP motors. Each of the RCPs is protected by a separate closed-head pre-action automatic water spray system that is installed under this hood. Each system has a ring header containing eight nozzles. The header is located approximately 4 feet above the top of the RCP motor and the nozzles, which actuate at 500 °F, are oriented so as to provide optimum coverage of the RCP motor from above. In addition, there are four rate-compensating/fixed-temperature spot-type thermal detectors located above the RCP motors on the bottom side of the heat-collection hood. These detectors are Class A supervised, have a thermal rating of between 200 °F and 225 °F and are alarmed and annunciated in the MCR. In the event of a fire, this hood acts as a ceiling, forcing the heat to stall around the detectors and the suppression nozzles, thus reducing the response time of these fire protection devices.

Based on its review of the information submitted by TVA, the NRC staff concludes that the RCP oil collection systems have been designed in accordance with Section III.O of Appendix R to 10 CFR Part 50. The deviations to allow collection of oil in the lower motor support housing and to allow minor amounts of oil to escape the oil collection system and become a thin film on piping mirror insulation and supports in the vicinity of the RCPs, are acceptable since large leakages would be alarmed to the control room and the RCP cubicles are equipped with fixed fire suppression and detection is provided.

6.1.9 Evaluation -Unit 2 Manual Actions

TVA committed to meet Section III.G of Appendix R to 10 CFR Part 50. Section III.G of Appendix R to 10 CFR Part 50 provides a number of acceptable methods of providing reasonable assurance that one of the safe shutdown trains is free of fire damage using a combination of physical separation, fire wraps, fire detection and fire suppression. Unless previously approved by the NRC, the use of OMAs is not a means of assuring that a safe shutdown train is free of fire damage, as described in Section III.G of Appendix R to 10 CFR Part 50. Discussion of OMAs needed for equipment important for safe shutdown is included in Section 3.5 of this evaluation.

TVA developed evaluations to demonstrate that OMAs are capable of accomplishing various safe shutdown functions and terminating spurious equipment operations that have the potential to interfere with safe shutdown. TVA also described the fire protection defense-in-depth features within each room that reduces the likelihood that an OMA would be needed. The NRC staff has reviewed the OMAs in the below captioned rooms.

Operator Manual Action Number	Room of Postulated Fire
OMA-1016	713.0-A1B‡, 737.0-A1B, 737.0-A1N*, 757.0-A1, 757.0-A5, 757.0-A10, 757.0-A17, 757.0-A22, 757.0-A24, 757.0-A28, 772.0-A2 East, 772.0-A5, 772.0-A8, 772.0-A15* East, 772.0-A15 West*, 782.0-A1, 782.0- A2

OMA-1022	713.0-A1A‡, 713.0-A27, 729.0-A8, 737.0-A1A, 737.0-A5S, 737.0-A9M, 737.0-A9N, 737.0-A9S, 757.0-A2, 757.0-A4‡, 757.0-A9, 757.0-A16, 757.0-A23, 757.0-A27, 772.0-A1, 772.0-A2 West, 772.0-A4‡, 772.0-A8, 772.0-A9, 772.0-A10, 772.0-A16, 782.0-A3, 782.0-A4
OMA-1023	713.0-A1A‡, 713.0-A1B‡, 713.0-A27, 729.0-A8, 737.0-A1A, 737.0-A1C, 737.0-A5M, 737.0-A5N, 737.0-A5S, 737.0-A9M, 737.0-A9N, 737.0-A9S, 757.0-A2, 757.0-A4‡, 757.0-A9, 757.0-A16, 757.0-A21, 757.0-A23, 757.0-A27, 772.0-A1, 772.0-A2 West, 772.0-A4‡, 772.0-A6, 772.0-A8, 772.0-A9, 772.0-A10, 772.0-A12, 772.0-A16, 782.0-A3, 782.0- A4, DBIPS-A‡, IPS-A‡,IPS-C Middle, IPS-C West
OMA-1023	737.0-A1B, 737.0-A1N*, 757.0-A12, 757.0-A1, 757.0-A3‡, 757.0-A5, 757.0-A10, 757.0-A17, 757.0-A22, 757.0-A24, 757.0-A26, 757.0-A28, 772.0-A2 East, 772.0-A8, 772.0-A11, 772.0-A15* East, 772.0-A15 West*, 782.0- A1, 782.0- A2, DBIPS-B‡, IPS-B‡, IPS-C East
OMA-1065	692.0-A25
OMA-1066	692.0-A25†
OMA-1159 & 1160	692.0-A1B*, 692.0-A22*
OMA-1275	713.0-A1B‡,
OMA-1444 & 1445	772.0-A15 East*‡, 772.0-A15 West*‡, 772.0- A16‡
OMA-1448	772.0-A15 West*‡
OMA-1488	772.0-A13‡
OMA-1489	772.0-A14‡
OMA-1495 & 1496‡	772.0-A15 West*
OMA-1515	713.0-A1B‡
OMA-1516 1517	757.0-A21‡
OMA-1535 1536	737.0-A1N*‡
OMA-1540 1542	737.0-A1B‡

Key:

* Lacks full area fire detection, automatic suppression, or other defense-in-depth features – reviewed as part of separate deviation.

† OMA involves re-entry into room with postulated fire.

‡ OMA for this area either lacks full detection, full suppression, or 40 minutes of time margin, or a combination of these features.

TVA used the guidance in NUREG-1852, "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire," in determining the feasibility and reliability of manual actions. The following criteria were used to consider feasibility and reliability: (1) Adequate Time Available to Perform Actions; and (2) Adequate Time Available to Ensure Reliability. Most manual actions that had at least 40 minutes of margin were considered feasible and reliable. This considered the estimated travel and performance of the OMA, based on time trials performed for Unit 1 OMAs. The diagnosis time for OMAs is discussed in Section 3.5.4 of this evaluation. For the OMAs listed above, demonstrations have been performed to show that there will be at least 40 minutes of remaining margin upon the completion of the OMAs.

Some of the OMAs that had less than 40 minutes of margin have been designated in the table above as having reduced feasibility and reliability. Each of these OMAs have been evaluated specifically below with due consideration to time margin, defense-in-depth features, and other characteristics that would impact the likelihood that the manual action would be needed and the likely successful performance of the manual action.

In some cases, re-entry of the fire area was considered after 60 minutes. These areas have automatic fire suppression, therefore the NRC staff considers re-entry in these cases to be acceptable. In other cases, the OMA may be needed in a room, but not the same room, on the same elevation as the postulated fire. In this event, TVA considered the possible environmental effects of the fire and concluded that those factors would not prevent the performance of the OMA. These areas had full suppression and detection, therefore this is considered acceptable by the NRC staff.

TVA also considered: (1) Environmental Factors, (2) Equipment Functionality and Accessibility, (3) Available Indications, (4) Communications, (5) Portable Equipment, (6) Personnel Protection Equipment, and (7) Procedures and Training. TVA stated that the above criteria do not adversely affect the performance of the action for the Unit 2 OMAs.

Fire protection defense-in-depth features, such as fire prevention, fire detection, and fire suppression apply to each of these rooms. Most rooms have full area fire detection and automatic fire suppression. For those areas that lack full fire area detection and automatic fire suppression, they are designated in the table with an asterisk. TVA performed an analysis of the fire hazards in the area and determined that the fire hazards in the area do not warrant the installation of fire detection and automatic suppression. These areas are typically pipe chases, tunnels, tank rooms, labyrinth entrances, corridors, or portions of larger rooms where the majority of the room is protected. The review of these systems is described in Section 6.1.7 of this evaluation.

Some rooms lack the typical full area detection and suppression and have not been evaluated previously. The FPR includes a description of the protection features in the room. For those rooms that lack full fire detection and automatic fire suppression, the NRC staff has evaluated these areas specifically below. This evaluation uses the available defense-in-depth information and information about the OMA to determine if having less than full area suppression and detection is acceptable. Using full area suppression and automatic detection as criteria for OMAs is not intended to imply that they are required; rather, the NRC staff deemed full detection and automatic suppression as a robust level of protection. Less than full detection and automatic suppression received a more detailed review by the NRC staff.

In its response by letter dated September 30, 2011 (ADAMS Accession No. ML13060A225), to NRC question RAI FPR VII-24, TVA stated that the operators that will be performing the manual actions could be working anywhere in the plant and would be summoned to the MCR, or the ACR for a control building fire, upon the confirmation of a fire. Upon arrival at the control room, the operators will receive their assignments and procedures. TVA included a description of where these OMAs are performed in sequence with other OMAs. Based on the information provided by TVA, the NRC staff concludes that the number of available operators is sufficient to perform the manual actions.

Evaluation of OMAs needed for fires in areas that lack fire detection or automatic suppression or both

Rooms 713.0-A1A and 713.0-A1B lack automatic suppression above the boric acid tanks. TVA stated that the area of the boric acid tanks is considered a combustible control zone, and that the automatic suppression in the immediate area would control the spread of fire. Therefore the NRC staff concludes this lack of full area suppression is acceptable.

Rooms 757.0-A3, 757.0-A4, 757.0-A22, 757.0-A23, 772.0-A4, 772.0-A13, and 772.0-A14, are equipped with ionization fire detection systems and manual fire sprinkler systems, rather than the typical automatic fire sprinkler system. These vital battery board rooms are described as having battery and instrument boards, transformers, control panels, and junction boxes. These combustibles are considered small as compared to typical power plant electrical panels, and TVA does not consider them credible ignition sources due to proper circuit protection and low concentrations of combustibles. Transient combustibles are controlled by plant procedures. OMAs 1016 (757.0-A22), 1022 (757.0-A4, 757.0-A23, and 772.0-A4), 1023 (757.0-A4, 757.0-A23, and 772.0-A4), 1024 (757.0-A3 and 757.0-A22), 1488 (772.0-A13), and 1489 (772.0-A14) each have at least 40 minutes of time margin. Based on the installed ionization fire detection systems, the manual fire suppression systems, the limited combustibles, and the available time margin, the NRC staff finds this evaluation is acceptable.

Rooms DBIPS-A and DBIPS-B, the IPS Duct Banks, have no detection or suppression. These areas have no credible ignition sources for the installed cables in the area. Since these are underground electrical conduit banks, no transient combustibles are expected. The manual actions that may be needed for fires in these duct banks are OMAs 1023 (DBIPS-A) and 1024 (DBIPS-B), and each have a 40-minute time margin. Based on the limited ignition sources for this underground duct bank, and the available time margin, the NRC staff finds these evaluations are acceptable.

Rooms IPS-A and IPS-B, the IPS areas A and B, have fire detection over the ECRW pumps and in each of the ERCW strainer rooms. Each area has a floor area in excess of 3500 square feet and a ceiling height of at least 13 feet. The combustibles in the room consist of the lubricating oil associated with the pumps, transformers, and MCCs. The OMAs 1023 (IPS-A), and 1024 (IPS-B) have 40-minute time margin. Based on the partial detection, the size of the rooms, and the available time margin, the NRC staff finds these evaluations are acceptable.

Evaluation of OMAs that lack 40 minutes of time margin

OMA 1275, for a fire in Room 713.0-A1B, lacks the typical minimum time margin of 40 minutes. The time margin for this action is analyzed to be 12 minutes for an action needed to be performed in 20 minutes. The demonstrated time for the comparable Unit 1 action was less than 8 minutes. This is the first action that the operator performing the OMA will do based on the analysis. The fire room is equipped with ionization smoke detection and an automatic sprinkler system. The room has a floor area of over 17,000 square feet and a ceiling height of 23 feet nominally. Based on the installed defense-in-depth features, the size of the fire area, and the demonstrated performance time of 8 minutes, the NRC staff finds this OMA is acceptable for this specific room.

OMAs 1444, 1445, and 1448, for a fire in Rooms 772.0-A15 East, 772.0-A15 West or 772.0-A16, must be completed within 18 minutes. OMA 1448 applies to 772.0-A15 West only.

Demonstration of comparable actions resulted in a demonstrated time of less than 2 minutes. This provides approximately 16 minutes of margin for these actions. The fire area is equipped with a fire detection and automatic sprinkler system. The room has a floor area of 2153 square feet and a nominal ceiling height of 13 feet. Based on the installed defense-in-depth features, the size of the fire area, and the demonstrated performance time of 2 minutes, the NRC staff finds these OMAs are acceptable for these specific rooms.

OMAs 1495 and 1496, for a fire in Room 772.0-A15 West, must be completed within 20 minutes. Demonstration of comparable actions resulted in a demonstrated time of less than 4 minutes. This provides approximately 16 minutes of margin for these actions. The fire area is equipped with fire detection and automatic suppression systems. The room has a floor area of 2153 square feet and a nominal ceiling height of 13 feet. Based on the installed defense-in-depth features, the size of the fire area, and the demonstrated performance time of 4 minutes, the NRC staff finds these OMAs are acceptable for this specific room.

OMAs 1516 and 1517, for a fire in Room 757.0-A21, must be completed within 20 minutes. Demonstration of similar actions, which have no preceding actions, for Unit 1 indicated a travel and performance time of less than 3 minutes. This provides approximately 17 minutes of margin for these actions. The fire area is equipped with fire detection and an automatic sprinkler system. The area has a floor area of 2244 square feet with a nominal ceiling height of 14 feet. Based on the installed defense-in-depth features and the demonstrated performance of the OMA in approximately 3 minutes, the NRC staff finds these OMAs are acceptable for this specific room.

OMAs 1535 and 1536, for a fire in Room 737.0-A1N, must be completed within 20 minutes. Demonstration of similar actions, which have no preceding actions, for Unit 1 indicated a travel and performance time of 3 minutes. This provides 17 minutes of margin for these actions. The fire area is equipped with fire detection and an automatic sprinkler system. The area has a floor area of 23,144 square feet with a nominal ceiling height of 19 feet. Based on the installed defense-in-depth features and the demonstrated performance of the OMAs in approximately 3 minutes, the NRC staff finds these OMAs are acceptable for this specific room.

OMAs 1540 and 1542, for a fire in Room 737.0-A1B, must be completed within 20 minutes. Demonstration of similar actions, including preceding actions, for Unit 1 indicated a travel and performance time of approximately 3 minutes. This provides 17 minutes of margin for these actions. The fire area is equipped with fire detection and an automatic sprinkler system. The area has a floor area of 23,144 square feet with a nominal ceiling height of 19 feet. Based on the installed defense-in-depth features and the demonstrated performance of the OMAs in approximately 3 minutes, the NRC staff finds these OMAs are acceptable for this specific room.

Conclusion – Unit 2 Manual Actions

The NRC staff reviewed the submitted information regarding these specific OMAs and the fire scenarios that would cause them to be performed. The NRC staff concludes that, based on the fire protection defense-in-depth features and the feasibility and reliability of the OMAs, performance of these manual actions provides reasonable assurance that the capability to safely shutdown will be available, and is, therefore, acceptable.

6.1.10 Evaluation – Fire Hazards Analysis in Lieu of 10 CFR 50, Appendix R, Section III.G.2 Separation

In FPR Part VII, Section 2.9, TVA stated that there are rooms at WBN that lack the separation required by Section III.G.2 of Appendix R to 10 CFR Part 50. For these rooms, TVA relied upon a fire hazards analysis and an analysis of the safe shutdown capability rather than OMAs. In many cases these rooms are part of larger fire areas.

For all the rooms included as part of this evaluation, transient combustibles and ignition sources have been reported by TVA to be controlled by plant procedures. TVA provided a justification why certain ignition sources were not considered credible ignition sources. In addition, separation between adjacent rooms has been evaluated and TVA concluded that no credible fire could spread either from or to adjacent rooms. TVA reported that room fires affecting the FSSD equipment would neither initiate nor require a plant trip.

6.1.10.1 Rooms without Credible Ignition Sources and Redundant Trains

- Rooms 692.0-A29 and 692.0-A30 – Boric Acid Evaporator Package Rooms A and B
- Rooms 729.0-A1 and 737.0-A6 – Unit 1 South Main Steam Valve Room and Air Lock
- Room 729.0-A2 – Unit 1 North Main Steam Valve Room
- Room 729.0-A6 – Nitrogen Storage Area
- Room 729.0-A10 – Unit 2 North Main Steam Valve Room
- Rooms 729.0-A11 and 737.0-A10 – Unit 2 South Main Steam Valve Room and Air Lock
- Room 729.0-A12 – Unit 1 Steam Valve Instrument Room A
- Room 729.0-A13 – Unit 2 Steam Valve Instrument Room A
- Rooms 729.0-A15 and 763.5-A2 Upper Head Injection Equipment Rooms

TVA evaluated fire protection defense-in-depth for these rooms. These rooms have been reported to have minimal combustible loading consisting of plastics associated with small components or grease and oil associated with valves. Cables related to FSSD cables are installed within these rooms within conduit. Air lines that have a related FSSD function may be installed within these areas and are of welded steel construction. Other than cables within conduit and welded steel air piping, no other FSSD equipment is installed in these rooms. TVA evaluated the installed equipment in these rooms and concluded that there are no credible in situ ignition sources. Other ignition sources and transient combustibles are controlled in accordance with plant procedures. TVA determined that, even without any installed fire detection or suppression, no fire scenarios could credibly affect the cables or air lines that are involved in plant safe shutdown. TVA has determined that for each of these areas, if fire damage were to occur to the installed equipment a plant trip would not be initiated or required.

The NRC staff reviewed the submitted deviation and concludes that, based on the fire protection defense-in-depth features, limited combustibles and ignition sources, combustible controls, and no fires affecting FSSD equipment that would either initiate or require a plant trip, the configurations for these specific features in these rooms is acceptable to meet the underlying purpose of the rule and is, therefore, acceptable.

6.1.10.2 Room 757.0-A13 – Refueling Floor and New Fuel Storage Vault

The refueling floor has two fixed ignition sources installed, specifically two auxiliary air compressor units and equipment associated with hydraulic cranes and hoists. The air compressors, although credible ignition sources, are more than 20 feet separated from each other with no intervening combustibles. Therefore, a fire affecting one compressor would not be expected to affect the other compressor. A failure of one of the compressors could cause the air supply system to lose supply pressure. The other train would be available. In addition, a low pressure alarm on the affected system would be annunciated in the MCR.

The crane and hoist are only in operation when plant personnel are operating them. Therefore, any fire would be quickly identified by personnel in the immediate vicinity, and this would provide assurance that other FSSD equipment would not be damaged.

The new fuel storage vault has negligible combustibles and no credible ignition sources.

The NRC staff reviewed the submitted deviation and concludes that, based on the fire protection defense-in-depth features, limited combustibles, combustible controls, separation between redundant trains within the room with no intervening combustibles, continuous staffing when cranes and hoists are used, and no fires affecting FSSD equipment that would either initiate or require a plant trip, the configurations for these specific features in this room is acceptable to meet the underlying purpose of the rule and is, therefore, acceptable.

6.1.10.3 Room 757.0-A14 – Unit 2 Reactor Building Access Room and Room 757.0-A15 – Unit 2 Reactor Building Equipment Hatch

In contrast to the other rooms evaluated, these rooms have more than minimal combustible loading. The combustible loading is composed primarily of thermoset cable. The electrical circuits in the cables have circuit protection that reduces the likelihood of a self-ignited cable fire. TVA reported that there are no credible ignition sources in these rooms. In addition, each of these rooms is equipped with fire detection and automatic fire suppression systems.

For each of these rooms TVA identified five sets of redundant components. Each set of components is discussed below.

SGs 2 and 3 Main Steam Isolation Valves – The main steam isolation valves (MSIVs) are normally energized and fire damage that deenergizes the train will cause the MSIVs to close. Closed is the normal safe shutdown configuration. The fire damage failure mode of concern is a sustained hot short that keeps the MSIVs open.

In the unlikely event that damage causes a sustained hot short, given the limited ignition sources, full area detection and automatic suppression, the main steam system can be isolated from the MCR using the steam load valves.

RCP Seal Injection – An instrument cable for control circuits for the valve that controls the charging flow is located in these rooms near the ceiling. Based on the limited ignition sources and installation of an automatic fire suppression system, fire damage at the ceiling of these rooms is unlikely. In the unlikely event that the control circuits are damaged and the control valve spuriously operates, the indication is available and MCR operators could operate the valve using a different pressurizer level input or manually.

Control Cable for SG 3 PORV – A control cable for SG 3 PORV is routed through these rooms. A hot short to the control cable would cause the PORV to close, and not to be used for safe shutdown. In the unlikely event that a fire were to start, given the limited ignition sources, and the fire was not extinguished by the installed fire suppression system, the location of the cable in conduit over 20 feet above the floor provides assurance that cable damage would not occur.

Main Feedwater Isolation for SGs 2 and 3 – Main feedwater isolation valve control cables are installed in conduit in these rooms. Fire damage to these cables could interfere with the isolation of main feed water. In the unlikely event that a fire were to start, given the limited ignition sources, and the fire was not extinguished by the installed fire suppression system, operators in the MCR would still have available indication and controls over other valves that would be available to isolate the main feedwater flow.

Main Feedwater Bypass Line Isolation Valve Circuits for SGs 2 and 3 – Main feedwater bypass lines could remain open upon concurrent hot shorts of the control cables. In the unlikely event that a fire were to start, given the limited ignition sources, and fire was not extinguished by the installed fire suppression system, the control valves could still be closed by operator actions from the MCR.

The NRC staff reviewed the submitted deviation and concludes that, based on the fire protection defense-in-depth features, limited ignition sources, available detection and suppression systems, and either cables located high above the floor or alternative ways of meeting the safe shutdown goals using MCR actions, the configurations for these specific features in these rooms is acceptable to meet the underlying purpose of the rule and is, therefore, acceptable.

6.1.10.4 Unit 2 Containment Rooms

- Room 2RIR – Unit 2 Reactor Instrument Room
- Rooms 2RA1, 2RA2, 2RA3, and 2RA4 – Unit 2 Accumulator Rooms 1, 2, 3, and 4
- Rooms 2RF1 and 2RF2 – Unit 2 Reactor Building Fan Rooms 1 and 2
- Rooms 2RI-1, 2RI-2, 2RI-3, and 2RI-4 – Unit 2 Reactor Building Inside Crane Wall Rooms
- Rooms 2RO-1, 2RO-2, 2RO-3, and 2RO-4 – Unit 2 Reactor Building Outside Crane Wall Rooms

TVA stated that these rooms have stronger combustible controls than other plant areas, since these areas are considered combustible control zones. In addition, many of these areas are inaccessible during power operations and involve the climbing of ladders for entry, which will reduce the likelihood of transient combustibles and ignition sources. TVA stated that none of these rooms have credible in situ ignition sources. TVA provided a discussion that concluded fires in adjoining rooms would not affect the FSSD equipment in these rooms, due to either lack of combustibles in adjoining rooms or installed automatic suppression and detection in the adjoining rooms. TVA stated that a fire in one of these rooms affecting FSSD equipment would neither initiate nor require a plant trip.

In addition to defense-in-depth features described above, the FSSD capability has one or more of the additional features that provide(s) additional assurance that a fire in one of these rooms will not challenge plant safe shutdown:

- Redundant cables are separated by at least 3 feet horizontally,
- Cables are installed in conduit,
- Alternative systems are available in the control room to shutdown the plant,
- Spurious actuations are avoided by the use of dedicated conduit with no other energized conductors,
- Spurious actuations are avoided since they would only occur if there were a proper polarity two or three phase hot short,
- Targets are high above the floor, at least 10 feet, and/or
- Redundant trains may be located in the analysis volume, but not in the room being evaluated.

Based on its review of the information submitted by TVA, the NRC staff concludes that the lack of separation in these rooms, is an acceptable deviation from Section III.G.2.d of Appendix R to 10 CFR Part 50, because of the limited combustibles and ignition sources, failure of the FSSD equipment or cables would not initiate or require a plant trip, and all redundant safe shutdown circuits have one or more of the additional criteria above.

6.2 Deviations and Evaluations Related to BTP (APSCB) 9.5-1, Appendix A Guidance

6.2.1 Deviation – Fire Detection in Refueling Room and New Fuel Storage Vault

TVA committed to the guidance in Positions F.12 and F.13 of Appendix A to BTP (APCSB) 9.5-1, which states that fire detectors should be installed in new fuel and spent fuel pool areas. Contrary to the guidance, the refueling room (Room 757.0-A13), which includes the New Fuel Storage Vault (elevation 741.5 feet), is not provided with a detection system.

TVA states that the refueling room is constructed of reinforced concrete. This room has a large open area with a floor area of approximately 16,000 square feet and a nominal ceiling height of 56 feet. The walls, floor and penetration seals have a fire resistance rating of 2 hours or greater. The doors are not UL listed doors, but have been evaluated as equivalent to fire rated doors as listed in the FPR Part II, Table 14.8.1 (Fire Doors). The dampers have a minimum rating of 2 hours.

During normal operations, the in situ combustible loading in the refueling room and the new fuel storage vault is insignificant, resulting in an equivalent fire severity of less than 5 minutes. There are no ignition sources in the new fuel storage vault. The combustible materials in the refueling room are widely dispersed, which further diminishes the magnitude of a postulated fire. The combustibles consist of InstaCote (a plastic type fuel transfer canal coating); lube oil in air compressors; hoists and cranes; plastics associated with the electrical equipment, panels, fuel pool boundary, lighting and boxes; rubber fire hose; and anticipated amounts of radwaste trash and laundry. TVA further stated that transient combustibles in the room are controlled by WBN procedure NPG-SPP-18.4.7,"Control of Transient Combustibles." The potential ignition sources in the room are panels, air compressors, transformers, and lighting cabinets. The only ignition sources that could impact a FSSD component or cable are the Train A and B auxiliary air compressors.

The room is manned during an outage, which can assist in the early detection of a fire. The new fuel storage vault is only accessible from the refueling room and that access is normally closed with a steel hatch cover. The cover is removed when new fuel is received and stored until needed for a refueling outage. Due to the high ceiling and limited amount of combustibles, a fire in this area may not have sufficient energy to create the necessary air currents to carry the smoke to the ceiling. In this situation, the smoke detectors at the ceiling level may not be able to provide early detection in the event of a fire.

Standpipe and hose stations are provided in the refueling room and in adjacent rooms.

The Train A and B auxiliary air compressors supply backup air to the Train A and B air header if the normal air supply from the station air compressors is unable to maintain minimum pressure on the air header. A fire involving either of the auxiliary air compressors would not impact the normal air supply or the other auxiliary air compressor. The worse case fire scenario would be a loss of one train of auxiliary control air, which would not require either unit to shutdown. The other FSSD circuits are routed in conduits in the refueling floor area and are outside the fire zone of influence of the compressors. Therefore, a fire in the refueling room will not impact FSSD capability.

Based on its review of the information submitted by TVA, the NRC staff concludes that the lack of fire detection in the refueling room, including the new fuel storage vault, as identified above, is an acceptable deviation to the guidance of Positions F.12 and F.13 of Appendix A to BTP (APCSB) 9.5-1, because of the size of the refueling room, the limited amounts of in situ and transient combustibles, the separation of the room from other plant areas by fire-rated barriers, and the routing of FSSD circuits in conduits away from credible ignition sources.

6.2.2 Deviation – Fire Doors

TVA committed to the guidance in Position D.1.j in Appendix A to BTP (APCSB) 9.5-1, which states that door openings should be protected with equivalently rated fire doors, frames, and hardware that have been tested and approved by a nationally recognized laboratory.

In FPR Part VII, Section 4.1, TVA stated that, contrary to the guidance, a number of fire doors have been altered by the addition of signs and security hardware, or have been damaged and repaired onsite. Additionally, special-purpose doors, such as flood doors and pressure doors, are not UL labeled.

The fire doors that are not listed or labeled as fire-rated assemblies have been evaluated to the guidance of NFPA 80-1975, "Fire Doors and Windows," by TVA or nationally recognized laboratories for fire door assemblies. The evaluation criteria for fire door assemblies is documented and controlled by WBN General Engineering Specification-73,"Installation, Modification and Maintenance of Fire Protection Systems and Features."

FPR Part II, Table 14.8.1 lists the plant fire doors and the doors' fire-rating in hours. The table identifies doors that are not UL listed as having been evaluated and identified as equivalent to fire rated doors or they have been evaluated as being acceptable. A number of the fire doors at WBN have been altered by the addition of signs and security hardware or have been damaged and repaired. Examples of other fire doors that are not UL rated are special purpose doors such as flood doors and pressure doors, security doors in the MCR that are constructed of heavy welded steel construction and hollow core metal swinging doors.

Based on its review of the information submitted by TVA, the NRC staff concludes that TVA has adequately justified that certain door assemblies which do not fully meet the guidance in Position D.1.j in Appendix A to BTP (APCSB) 9.5-1 are acceptable, because the doors were evaluated to the guidance of NFPA 80-1975, and WBN General Engineering Specification-73 controls and documents the installation, modifications and maintenance of fire doors.

6.2.3 Deviation – Openings in Fire Walls

TVA committed to the guidance in Section D.1.j of Appendix A to BTP (APCSB) 9.5-1, which states that fire barriers should be capable of withstanding the fire hazards to which they could be exposed. NRC generic letters and guidance documents state that penetrations in walls, floors, and ceilings forming part of a fire barrier should be protected with seals or closure devices having a fire resistive rating equivalent to that required of the barrier.

In FPR Part VII, Section 4.2, TVA stated that there is a 6-inch wide by 3-inch deep gutter that penetrates each stairwell enclosure (Stairwells C1 and C2) from the corridor (Room 692.0-C11) in the control building.

These two stairwells are located at the opposite ends of the corridor (approximately 70 feet apart). The gutter penetrates the walls separating the stairwells from the corridor. Located in the gutter, there is one floor drain in each stairwell and two floor drains in the corridor.

The in situ combustible loading for the corridor is low and results in an equivalent fire severity of less than 20 minutes. The corridor is provided with a pre-action sprinkler system that is actuated by an ionization detection system. Standpipe and hose stations are in the two stairwells and portable extinguishers are provided in the corridor.

The in situ combustible liquids on elevation 692.0 feet of the control building are 35 gallons of lube oil associated with each of the two electrical board room chiller packages. The chiller packages are located in the Unit 2 mechanical equipment room, which is not part of Stairwells C1 or C2 or the corridor. However, the room is separated from Stairwell C2 by a 2-hour reinforced concrete wall. The combustibles in the Unit 2 mechanical equipment room consist of lube oil in the chillers, plastics associated with the electrical panels, boxes, lights and insulation on piping. The in situ combustible loading in this room is low resulting in an equivalent fire severity of less than 5 minutes. This room also has full detection and suppression installed.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the low in situ combustible loading in the corridor, installed fire detection and suppression systems, available standpipe and hose stations in the two stairwells and portable extinguishers in the corridor, this deviation from Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 for the corridor gutter that penetrate Stairwells C1 and C2 on control building elevation 692 feet is acceptable.

6.2.4 Deviation – Manual Hose Stations

TVA committed to the guidance in Section E.3.d of Appendix A to BTP (APCSB) 9.5-1, which states that interior manual hose installations should be able to reach any location with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 75 feet of 1-1/2 inch woven jacket lined fire hose and suitable nozzles should be provided.

In FPR Part VII, Section 4.3, TVA stated that there are manual hose stations with more than 75 feet of 1-1/2 inch UL listed or FM-approved fire hose located throughout the plant. The pressure loss in fire hoses due to conditions such as friction with the inner wall of the hose and turbulent water flow is directly proportional to the length of the hose. If the pressure loss is excessive the hose stream may not be effective.

To justify the use of hoses of greater than 75 feet in length up to 100 feet in length, TVA stated that these installations are consistent with the guidelines of NFPA 14-1974, "Standard for the Installation of Standpipe and Hose Systems," which allow up to 100 feet of hose connected to the standpipe.

For hose stations with more than 100 feet of hose, TVA stated that although those specific hose stations may not have been tested, hose stations at a higher elevation in the respective buildings were tested at a minimum of 65 psig at 500 gpm at a 2.5-inch hose connection. Also, TVA has calculated that there is 6 psi additional pressure loss for each additional 25 foot section of hose. TVA stated, in their letter dated May 30, 2012 (ADAMS Accession No. ML12153A374), that the tested hose stations are 31.5 feet higher in elevation than the hose stations with the additional hose. TVA calculated that 31.5 feet of elevation equates to approximately 13.5 psig of additional pressure at the lower elevation. This additional pressure on lower elevations would provide sufficient additional pressure to compensate for the approximately 6 psi of pressure loss for each of the two additional hose sections, and therefore would provide sufficient pressure and flow to meet the requirements of NFPA 14-1974.

Based on its review of the information submitted by TVA, the NRC staff concludes that the hose stations that have more than 75 feet of hose, as identified above, are acceptable deviations to the guidance of Section E.3.d of Appendix A to BTP 9.5-1.

6.2.5 Deviation – Fire Barrier Penetration between Fuel Oil Transfer Pump Room and the Diesel Generator Building Corridor

TVA committed to the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1, which states that penetrations in fire barriers, including conduits and piping, should be sealed or closed to provide a fire resistance rating at least equal to that of the fire barrier itself. The fire hazard in each area should be evaluated to determine barrier requirements.

In FPR Part VII, Section 4.6, TVA stated that the fire barrier separating the fuel oil transfer pump room (Room 742.0-D8) from the diesel generator building corridor (Room 742.0-D9) is a 2-hour rated fire barrier and has a penetration containing a steel box. This penetration is not a tested fire-rated penetration assembly.

The fire barrier separating the fuel oil transfer pump room and the corridor is constructed of 8-inch thick reinforced concrete block and is fire-rated for 2 hours. The annular gap between the block wall and the box is filled with concrete grout, but no sealant material is installed within the box. The box back (inside the fuel oil transfer pump room) is a steel plate. The front of the panel is a steel plate with cutouts for three metal junction boxes.

The in situ combustible loading of the fuel oil transfer pump room is approximately 3,730 Btu/ft2 and is due to insulation on cables associated with panel 0-L-162, hand switches, an emergency lighting unit, and foam plastic insulation. The in situ combustible loading of the corridor is approximately 77,700 Btu/ft2 of which approximately 96 percent is due to insulation on cables in cable trays. The other in situ combustibles are dispersed throughout the corridor and do not present a direct exposure hazard to the box. The corridor width at the panel is approximately

6 feet. The door into the 2B-B diesel generator is across from the box and the door to the fuel oil transfer pump room is next to the box. The end of the corridor is less than 6 feet from this door. TVA stated that this arrangement minimizes the probability of transient combustibles being stored near the box.

The fuel oil transfer pump room is provided with a fire detection system and a total flooding automatic CO2 suppression system. The detection system alarms in the MCR and actuates the suppression system. The corridor is provided with a fire detection system and an automatic sprinkler system. The detection system alarms in the MCR and actuates the suppression system. Upon receipt of a detection alarm, the MCR staff notifies the site fire brigade for both rooms.

The top of the box is located approximately 13 feet below the ceiling. TVA stated that in light of this distance and the location of the box at the end of the corridor, the detection system should alarm the MCR and actuate the suppression system before a hot gas layer could challenge the box.

TVA stated that the fuel oil transfer pump room and the corridor (analysis volume AV-081B) do not contain components required for safe shutdown in the event of a fire in these rooms. The small amount of in situ combustibles and the lack of free floor space limit the quantity of transient combustibles, thereby limiting the severity of a postulated fire in the room. The failure of a fuel oil line or pump that resulted in a fire is addressed by the total flooding, automatic CO2 suppression system that will also control a postulated transient fire until the fire brigade responds.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the penetration configuration and installed fire detection and automatic suppression systems, this configuration is adequate to prevent the passage of flames, hot gases or water from the corridor to the fuel oil transfer pump room or vice versa, and therefore, this non-tested, non-fire-rated penetration assembly is an acceptable deviation to the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.6 Deviation – Undampered Penetrations between the Unit 1 Pipe Gallery and the Unit 1 Annulus and the Unit 2 Pipe Gallery and the Unit 2 Annulus

In FPR Part VII, Section 3.2, TVA stated that the walls separating the Unit 1 pipe gallery (Room 713.0-A6) from the Unit 1 Annulus and the Unit 2 pipe gallery (Room 713.0-A19) from the Unit 2 Annulus are 3-hour rated fire barriers. The containment purge air system return and exhaust ducts penetrate these walls in three places. The penetrations are not provided with fire dampers.

TVA provided the following details regarding these configurations:

- The ducts are constructed of 0.25 inch thick steel plates and welded schedule 10 pipe.
- As described in TVA's letter dated October 28, 2011 (ADAMS Accession No. ML11306A090), in response to NRC question RAI FPR VII-32, the connection between the duct and the purge air system is protected by 3M M20A wrap.
- The ducts are rigidly attached to the concrete wall.

- The penetrations are not straight-through, instead the openings in the concrete wall are offset to provide radiation protection.
- The ducts have no openings in the pipe chase.
- There is automatic detection and suppression installed in the annuluses and pipe chases.
- The two annuluses and the areas under the ducts in the pipe chases are combustible control zones.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the physical configuration, installed fire protection systems, and administrative controls, the lack of fire dampers in these penetrations is an acceptable deviation from the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.7 Deviation – Openings in Fire Barriers

Section D.1.j of Appendix A to BTP (APCSB) 9.5-1, "Guidelines for Fire Protection for Nuclear Plants Docketed Prior to July 1, 1976," specifies that penetrations in walls, floors, and ceiling forming part of a fire barrier be protected with self-closure devices having a fire-resistive rating equivalent to that of the barrier.

6.2.7.1 Ventilation and Purge Air Room Ventilation Penetrations

In FPR Part VII, Section 2.6.1, TVA stated that the ventilation and purge air (VPA) rooms (Rooms 737.0-A5 and 737.0-A9), the post-accident sampling system (PAS) rooms (Rooms 729.0-A8 and 729.0-A9) and the nitrogen storage room (Room 729.0-A6) are separated by 2-hour fire rated barriers. The walls and floor of the VPA rooms are penetrated by HVAC ducts that pass from the PAS rooms, enter the VPA rooms and then exit into the PAS and nitrogen storage room. TVA stated that the ducts have no fire dampers, but they also have no openings into the VPA rooms. Additionally, one duct enters each VPA room from the nitrogen storage room and terminates at a normally closed isolation damper. The ducts are constructed from Schedule 40 carbon steel pipe. Pipe sleeves are provided where the ducts penetrate the barriers between the VPA rooms and the PAS rooms and nitrogen storage rooms. Further, the annular space between the sleeves and the ducts is sealed with a fire-rated seal.

TVA stated that each of these rooms contains safe shutdown equipment. TVA further stated that the VPA and PAS rooms have fire detection and automatic fire suppression systems installed, and the nitrogen storage room has ionization smoke detection. Standpipe and hose systems are available in adjacent rooms and portable extinguishers are also available for manual fire-fighting in these rooms.

TVA stated that the significant fire exposure to the ducts from the VPA rooms consists of charcoal filter units in each VPA room. TVA also stated that closed-head water-spray suppression systems are provided for the charcoal filters and are actuated by duct-mounted ionization smoke detectors.

TVA stated that the effect of a fire in the PAS rooms or the nitrogen storage room would be experienced in the VPA rooms in the form of radiant heat from hot gases passing through the ducts. In the VPA rooms, TVA stated that no fixed combustibles are located in the immediate vicinity of these ducts, and the ducts are separated from the nearest safe shutdown circuit by more than 20 feet.

Based on the limited fire hazard, the installed fire detection and automatic fire suppression systems, the special hazard protection for the charcoal filters, and the construction of the ducts, the NRC staff concludes that the ducts will remain in place until a fire is extinguished and that the absence of fire dampers will not lead to fire propagation from one room to another. Therefore, this duct configuration is an acceptable deviation from the guidance of Section D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.7.2 Scuppers

6.2.7.2.1 ERCW Pump Room

TVA committed to the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1, which states that penetrations in fire barriers, including conduits and piping, be sealed or closed to provide a fire resistance rating at least equal to that of the fire barrier itself.

In FPR Part VII, Section 2.6.2.1, TVA stated that, contrary to Position D.1.j, on elevation 741.0 feet of the IPS, there are four scupper openings penetrating the fire wall between the ERCW pump rooms and traveling screen rooms.

The wall separating the redundant ERCW pumps and the wall separating the ERCW pumps from the traveling screen pumps are 3-hour fire-rated barriers with the exception of the four scupper openings. These scupper openings are located at the floor and provide drainage of rainwater from the ERCW pump rooms to the traveling screen wells. The floor slopes away from the ERCW pumps toward the scuppers so that a fire in one ERCW pump room will not propagate through the scuppers and jeopardize a redundant train of ERCW pumps.

The wall separating the ERCW pump rooms and traveling screen rooms is intended to protect the rooms from the radiant heat of an exposure fire. The roof is designed as a missile shield and has beams that will allow free air flow from a fire to dissipate heat to the outside environment. ERCW Pump Rooms A and B have heat detectors installed over the ERCW pumps and standpipe and hose stations are accessible for manual fire-fighting activities. TVA stated that even though these rooms are not provided with suppression and full area detection, the fire area barrier ratings are sufficient given the combustible loadings in the area.

Based on its review of the information submitted by TVA, the NRC staff concludes that the scupper configuration for the wall separating the ERCW pump rooms from the adjacent traveling screen rooms is an acceptable deviation from the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5.1.

6.2.7.2.2 Yard Duct Bank

TVA committed to the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 which states that penetrations in fire barriers, including conduits and piping, be sealed or closed to provide a fire resistance rating at least equal to that of the fire barrier itself.

In FPR Part VII, Section 2.6.2.1, TVA stated that contrary to Position D.1.j, there are scupper openings in the Train A and Train B yard duct banks that run from the auxiliary building to the IPS where they share a common wall in three manholes.

Manholes 1A and 1B, 2A and 2B, and 3A and 3B are used to access the Train A and Train B duct banks that connect the auxiliary building to the IPS. The Train A and Train B duct banks are separated by a 12-inch thick reinforced concrete wall at each pair of manholes. One manhole in each pair contains a sump pump and is connected to the other manhole by a 2-inch diameter scupper opening. There are no other openings in the common wall separating the Train A and Train B manholes.

Cable insulation is the only combustible material in the yard duct banks where they share a common wall. The sump pumps are the only equipment in the yard duct banks where they share a common wall.

TVA stated that a postulated fire in the cable insulation of one duct bank or in the sump pump will not propagate through the scupper openings to the adjacent duct bank due to the lack of continuity of combustible materials between duct banks.

Based on its review of the information submitted by TVA, the NRC staff concludes that the scupper openings in the yard duct banks is an acceptable deviation from the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5.1.

6.2.7.3 Auxiliary Building Penetrations

In FPR Part VII, Section 2.6.3, TVA described the following unprotected openings in the auxiliary building:

- *Open Stairs and Hatches.* TVA stated that water curtains designed in accordance with NFPA 13-1974, Section 4-4.8.2, have been installed to protect the openings listed in FPR Part VII, Section 2.6.3.1.
- *Sheet Metal Ducts That Are Not Provided with Fire Dampers.* TVA stated that these ducts are constructed of minimum 22 gauge sheet metal, are securely fastened to the fire barrier with angle steel, and that automatic suppression and detection is provided on at least one side of the opening. Finally, TVA stated that the safe shutdown analysis considered these openings as unprotected and ensured that a fire on either side of the opening would not impact both paths of redundant safe shutdown components, cables, or equipment.
- *Round HVAC Ducts Constructed of Spiral Welded Pipe or Schedule 10 Piping.* TVA stated that these ducts are treated as normal mechanical penetrations with an appropriate fire rated mechanical penetration seals.
- *Spare Conduit Sleeves.* As described in FPR Part VII, Section 2.6.3.3, TVA stated that spare conduit sleeves which penetrate fire barriers are provided with approved sealant material, capped on each end with metal caps or plugs, or a combination of the two.

- *Unrated Steel Hatches into Monolithic Concrete Enclosures.* As described in FPR Part VII, Section 2.6.3.4, TVA stated that the monolithic enclosures in which the steel hatches are located are not open to other rooms on other elevations. Further, TVA stated that there are no safe shutdown cables or components within the monolithic enclosures.

Based its review of the information submitted by TVA, the NRC staff concludes that these configurations are acceptable deviations from the guidance of Section D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.7.4 Control Building Equipment Hatches to the Turbine Building

In FPR Part VII, Section 2.6.4, TVA stated that the mechanical equipment rooms in the control building (Rooms 692.0-C1 and 692.0-C10) are provided with equipment hatches in the ceiling separating them from the turbine building. The equipment hatches have flush fitting steel covers which are not fire rated. TVA stated that the covers are vital area boundaries with access control and security features attached to the undersides, to prevent inadvertent removal.

TVA stated that the covers do not form a water tight seal, but will limit any flammable and combustible liquid spills through the hatch openings into the control building mechanical equipment rooms. Seepage could occur around the perimeter where the covers are mounted to the floor and through the small diameter holes in the covers that are provided to facilitate their removal.

TVA stated that there are no safe shutdown components in the turbine building within 20 feet of the equipment hatches, so that a fire that spreads up into the turbine building will not impact FSSD capability. Further, TVA stated that the mechanical equipment rooms are provided with automatic detection and pre-action sprinkler systems, including sidewall heads in the vicinity of the hatches. TVA stated that the installed detection and suppression systems would control or extinguish postulated fires passing through the hatch covers prior to arrival of the fire brigade.

Based on its review of the information submitted by TVA on the cover configuration, separation between FSSD equipment, and installed fire protection systems, the NRC staff concludes that the hatch covers are acceptable deviations from the guidance of Section D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.8 Evaluation – Large Fire Dampers

TVA committed to the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1, which states that fire dampers should be tested and approved by a nationally recognized laboratory and the tests shall bound the installed configurations. In FPR Part VII, Section 3.4, TVA stated that in a December 12, 1984, report, UL stated that the maximum sizes of dampers covered by their classification and follow-up service program are 90 inches wide by 72 inches high in multiple assemblies (maximum sections being 30 inches wide by 36 inches high) and that dampers exceeding this are not eligible to be labeled. Contrary to this, fire dampers 1-ISD-31-3807 and 2-ISD-31-3882 consist of four 24-inch wide and 24½-inch high damper sections resulting in an opening 98" inches wide by 24½ inches high. This exceeds the UL rated damper width by 8" inches.

TVA further stated that fire tests reports dated June 15 and July 19, 1984, document the results of tests conducted by UL for Ruskin (the damper manufacturer) on large size damper installations. The large damper configurations in the two tests (100 inches by 91 inches and 100 inches by 72 inches) both passed the 3-hour fire endurance acceptance criteria by remaining in place and not having an opening in the damper configuration. Both configurations, however, failed the hose stream test at the end of the 3-hour fire exposure. The report dated December 12, 1984, documented UL's evaluation of WBN's installation of the large dampers.

The large fire damper installations at WBN are constructed from individual damper sections which are smaller than the maximum allowed by UL. The UL listed assembly is three sections wide by two sections high, but the WBN configuration is one section high and four sections wide, thus making the assembly more rigid and less susceptible to buckling and twisting under actual fire conditions. Also, the individual damper sections are 24 inches wide by 24½ inches high, which are less than the UL allowable 30 inches wide by 36 inches high. The overall damper height is 24½ inches high, and the UL allowable height is 72 inches, when two 36 inch dampers are stacked.

In the December 12, 1984, report, UL indicated that the WBN dampers (98" inches wide by 24½ inches high) should have significantly less buckling and twisting of the vertical mullions than the tested damper (91 inches wide and 72 inches high) noted in the June 15, 1984, report. UL also concluded that the large damper installations at WBN provide adequate protection for their HVAC penetration.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the UL review, TVA has adequately justified the above non-tested fire dampers that do not fully meet the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1; therefore, the deviation from the guidance is acceptable.

6.2.9 Evaluation – Emergency Diesel Generators 7 Day Storage Tanks

TVA committed to the guidance in Position F.10 of Appendix A to BTP (APCSB) 9.5-1, which states that diesel fuel oil tanks with a capacity of over 1100 gallons should not be located inside buildings containing safety-related equipment. If located inside such buildings, the tanks should be separated by 3-hour fire barriers. Buried tanks are considered to meet the 3-hour fire resistance requirements.

In FPR Part VII, Section 4.4, TVA stated that there are four 7-day (70,248 gallon) storage tank assemblies, one per diesel generator, that are almost entirely buried below the floor of the diesel building. The fuel oil storage assembly for each diesel generator consists of four interconnected tanks, each with its own man-way access openings, one at either end of the tank. There are a total of 16 man-way access openings to the tanks from the corridor, and four in each diesel generator room. The man-way access openings are the only portion of the tanks that are not buried underneath the floor of the diesel generator building.

Each man-way access opening is in a pit covered by a removable plate cover sitting over the top of the pit flush with the floor. The cover is 1/4 inch thick steel plate, secured to the top of the tank by eighteen (18) 1/2 inch bolts. There are three normally closed openings in the cover plate. Two of the openings are provided for fuel oil circulation, and the other is for taking fuel oil samples.

The Pipe Gallery and Corridor (Room 742.0-D9) and Diesel Generator Units 1A-A, 2A-A, 1B-B and 2B-B (Rooms 742.0-D4, D5, D6 and D7) are provided with full area detection and automatic suppression systems. The diesel generator units each have heat detectors and a total flooding CO2 suppression system. Standpipe and hose stations are provided within the diesel generator building on both elevations, and there are also fire hydrants available in the yard. The Pipe Gallery and Corridor has smoke detectors and an automatic pre-action sprinkler system. A standpipe and hose station is provided in the Pipe Gallery and Corridor.

Fire affects on the emergency diesel generators and associated cables in the diesel generator building will not have an adverse affect on safe shutdown. The diesel generators are not credited for any fire in the diesel generator building. The diesel generator building is located remotely from other buildings containing equipment or cables needed for safe shutdown. This is because offsite power capabilities have been evaluated and determined not to be affected or required for a fire in the diesel generator building, including the corridor.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the physical construction of the man-way access openings, the man-way access openings being the only portion of the tanks that are not buried, the installed detection and suppression systems installed, the diesel generators not being required for any fire in the diesel generator building, location of the diesel generator building, and offsite power capabilities not being affected by a diesel generator building fire, the man-ways not being totally buried is an acceptable deviation from the guidance in Position F.10 of Appendix A to BTP (APCSB) 9.5-1.

6.2.10 Evaluation – Fire Dampers in the VCT Room Doors

In FPR Part VII, Section 3.5, TVA stated that a fire damper in the door connecting each of the two VCT rooms with the associated pipe gallery has been changed from a blade-type to a curtain-type configuration. The new dampers are damper/sleeve assemblies, installed with the damper inside the doors. The sleeve extends a short distance on each side of the opening. The door was tested with the original damper, but not with the new damper.

TVA provided the following details regarding these configurations:

- The combustible loading in the immediate vicinity of the doors is insignificant.
- The new dampers are listed dampers.
- The rooms on both sides of the doors are provided with automatic fire detection and suppression.

Based on its review of the information submitted by TVA, the NRC staff concludes that, based on the physical configuration, installed fire protection systems, and limited combustibles in the area, the change in these fire dampers is an acceptable deviation from the guidance in Position D.1.j of Appendix A to BTP (APCSB) 9.5-1.

6.2.11 Evaluation – Plexiglass Windows in the Security Control Point Building on the Refueling Floor

TVA committed to the guidance in Position D.1.d in Appendix A to BTP (APCSB) 9.5-1, which states, in part, that interior finishes should be noncombustible or have a flame spread rating of 25 or less.

In FPR Part VIII, TVA stated that, contrary to the guidance, the windows in a security control point building (on the 757.0 feet elevation on the Refueling Floor) was built with plexiglass windows, which do not meet the flame spread criteria. TVA stated the following concerning the plexiglass windows:

- Based on operating experience at Sequoyah Nuclear Plant, (i.e., a near-miss incident), glass windows pose a safety concern.
- Available alternatives either do not meet the flame spread criteria, or are not sufficiently transparent.
- The plexiglass windows add an insignificant amount of combustibles to a large room.
- The plexiglass windows have no effect on the safe shutdown analysis.
- The building is not used for safe shutdown.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the minimal amount of combustibles involved and the lack of an effect on safe shutdown, the presence of the plexiglass windows in the security control point building on the Refueling Floor is an acceptable deviation from the guidance in Position D.1.d of Appendix A to BTP (APCSB) 9.5-1.

6.3 <u>Additional Engineering Evaluations</u>

6.3.1 Relaxation of FPR Surveillance Frequencies for the Reactor Buildings' Equipment Hatches

FPR Part VII, Section 6.1, summarizes TVA's evaluation of relaxing the surveillance frequencies for fire protection features (smoke detectors, sprinklers, Thermo-Lag, penetration seals) from their regular schedules for the equipment hatches (Rooms 757.0-A11 and -A15). TVA stated that these actions will be performed during outages, because these areas are inaccessible high radiation areas while the associated unit is operating.

These rooms connect the refueling floor and the reactor buildings, and provide equipment access. TVA stated that the rooms are constructed of reinforced concrete and are provided with smoke detectors and automatic pre-action sprinkler systems. FPR Part VI states that the rooms' barriers are 3-hour fire-rated, with the exception of the blast door into the reactor building. TVA stated that these doors are of heavy metal construction that would prevent a fire from propagating from either the reactor building into the room or from the room into the reactor building. TVA further stated that combustible loading in the rooms is comprised of cable insulation, light covers, and Thermo-Lag (Room 757.0-A11 only), and that there are no ignition sources in the rooms during power operation.

Based on its review of the information submitted by TVA, the NRC staff concludes that the described change in surveillance frequencies is reasonable to meet the ALARA radiation exposure requirements in 10 CFR Part 20, "Standards for Protection against Radiation," and, therefore, is acceptable.

6.3.2 Relaxation of FPR Surveillance Requirements for Fire Dampers in High Radiation and Contaminated Areas

In FPR Part VII, Section 6.2, TVA evaluated the need to perform surveillance for fire dampers in high radiation or contaminated areas. TVA evaluated the consequences of the failure of the following fire dampers to close during a fire event: 0-ISD-31-3846, 0-ISD-31-3847, and 0-ISD-31-3848. TVA stated that these fire dampers are located in contaminated areas and are considered to be inaccessible.

6.3.2.1 Fire Damper 0-ISD-31-3846

TVA stated that fire damper 0-ISD-31-3846 is located in a 24-inch diameter embedded duct that starts at an embedded collector box located in the Fuel Transfer Canal wall and runs for 40 feet where it exits the concrete wall of the ventilation and purge air room (Room 737.0-A5) and then enters a large (64 inch by 54 inch) duct.

TVA also stated that there is no combustible hazard in the fuel transfer canal, and negligible quantities of combustibles in the vicinity of the duct in the ventilation and purge air room. TVA further stated that the room is provided with smoke detection and automatic suppression. Finally, TVA stated that should a fire breach the walls of the duct in the ventilation and purge air room, the fire would have to travel a distance of 40 feet to reach the fuel transfer canal.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited combustibles in each room, the distance the fire would have to reach the other room, the automatic suppression installed in the ventilation and purge air room, and the ALARA concern identified by TVA, not performing surveillance of this fire damper is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.2.2 Fire Dampers 0-ISD-31-3847 and 0-ISD-31-3848

TVA stated that one of the fire dampers is located in a 24-inch diameter embedded duct that starts at an embedded collector box located in the spent fuel pit wall, runs for approximately 5 feet where it exits the concrete wall, traverses a corridor, and penetrates the concrete wall of the ventilation and purge air room, and then enters a large (58 inch by 54 inch) duct. TVA stated that the other fire damper is located in a 30-inch diameter embedded duct that starts at an embedded collector box located in the opposite wall of the spent fuel pit, runs for approximately 80 feet where it exits the spent fuel pit wall (near the 24-inch duct), traverses the corridor, and penetrates the wall of the ventilation and purge air room and enters the large duct.

TVA stated that both ducts are coated with 2-inches of fire protective material (Pyrocrete) where they traverse the corridor. Further, TVA stated that there are no combustible hazards in the spent fuel pit, and negligible quantities of combustibles in the vicinity of the ducts in the corridor and near the ducts in the ventilation and purge air room. In addition, the corridor and the ventilation and purge air room are provided with smoke detection and the ventilation and purge air room is also provided with automatic suppression. Finally, TVA stated that should a fire breach the walls of the ducts in the ventilation and purge air room, the fire would have to travel a distance of 10 feet or 80 feet to reach the spent fuel pit, which is filled with water.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited combustibles in each room, the distance the fire would have to reach the other room, the automatic suppression installed in the ventilation and purge air room, and the ALARA concern identified by TVA, not performing surveillance of these two fire dampers is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.3 Gap between Door and Frame for Fire Door W9

In FPR Part VII, Section 6.3, TVA stated that a portion of the gap between the door and frame of fire door W9 exceeds the maximum 3/16-inch clearance. TVA further stated that the fire door is located in the wall that separates the RCW pump deck from the Train A ERCW pump room. TVA stated the following concerning the environment of door W9:

- The RCW pump deck is open to the atmosphere on three sides and does not have a roof.
- The ERCW pump room does not have a roof.
- The nearest RCW pump is located 17 feet horizontally from the door and the bottom of the door is 13.5 feet above the RCW pump deck.
- The in situ combustible load of the RCW pump deck consists primarily of lube oil associated with the RCW pumps.
- There are no in situ combustibles located directly under the door and the stairs and landings prevent any appreciable quantities of transient combustibles from being stored under the door.
- The door opens into a labyrinth that does not contain any in situ combustibles, nor are transient combustibles stored in the labyrinth.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the physical configuration that would prevent the formation of a hot gas layer, the distance to the nearest source of combustibles, and limited amount of combustibles in this area, exceeding the allowable door to frame distance for fire door W9, as described in the FPR, is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.4 Relaxation of FPR Surveillance Requirements for Penetration Seals in High Radiation and Contaminated Areas

In FPR Part VII, Section 6.4, TVA evaluated the need to perform surveillance for penetration seals in high radiation areas by evaluating the consequences of the failure of the penetration seals for each of the rooms. TVA stated that their evaluations considered the locations not inspected, the proximity of combustibles, and the construction features of the rooms on either side of the seals.

6.3.4.1 Spent Resin Tank Room (Room 692.0-A15)

TVA stated that the penetration seals of interest in Room 692.0-A15 are installed in the wall separating it from the pipe gallery and chase room (Room 692.0-A24), which is a 2-hour rated fire barrier of reinforced concrete construction. TVA stated that the penetration seals are accessible for surveillance inspection from Room 692.0-A24, however, they are not accessible for inspection from the spent resin tank room due to the radiation posting of the room.

TVA stated that there is no safe shutdown equipment in the spent resin tank room. FPR Part VI stated that the combustible loading in both rooms is insignificant. TVA also stated that there is smoke detection installed in Room 692.0-A24.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the minimal amount of combustibles in each room, the lack of safe shutdown equipment or cables in the spent resin tank room, the automatic smoke detection installed in the pipe gallery and chase room, and the ALARA concern identified by TVA, performing surveillance of these penetration seals from only one side is consistent with Interpretation 4, "Fire Area Boundaries," of NRC GL 86-10, and therefore, is acceptable.

6.3.4.2 Waste Hold Up Tank Room (Room 674.0-A1)

TVA stated that the penetration seals of interest in Room 674.0-A1 are installed in the wall separating it from the RHR Pump Room 1A-A (Room 676.0-A11) which is a 2-hour fire rated barrier of reinforced concrete construction. TVA stated that the penetration seals are accessible for surveillance inspection from Room 676.0-A11; however, they are not accessible for inspection from Room 674.0-A1 due to the radiation posting of the room.

TVA stated that there is no safe shutdown equipment required for a fire in the auxiliary building installed in the waste hold up tank room. FPR Part VI stated that the combustible loading in both rooms is insignificant. TVA also stated that there is smoke detection installed in Room 676.0-A11.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited amount of combustibles in each room, the lack of safe shutdown equipment or cables in the waste hold up tank room, the automatic smoke detection installed in the RHR Pump Room 1A-A, and the ALARA concern identified by TVA, performing surveillance of these penetration seals from only one side is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.4.3 Hold Up Tank Rooms A and B (Rooms 676.0-A2 and 676.0-A3)

TVA stated that Rooms 676.0-A2 and 676.0-A3 are separated from adjacent non-high radiation area rooms by 2-and 3-hour fire rated barriers of reinforced concrete construction. TVA stated that the penetration seals are accessible for surveillance inspection from these adjacent rooms. The penetrations are not accessible from inside the hold up tank rooms for surveillance inspection due to the radiation posting of the rooms.

TVA stated that there is no safe shutdown equipment installed in the hold up tank rooms, nor any equipment that could initiate a plant trip. FPR Part VI stated that the combustible loading in both rooms is insignificant. Additionally, TVA stated that all the adjacent rooms which contain cables or equipment needed for FSSD have installed smoke detection.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited amount of combustibles in these rooms, the lack of safe shutdown equipment or cables in the hold up tank room, the automatic smoke detection installed in the adjacent rooms which contain FSSD equipment or cables, and the ALARA concern identified by TVA, performing surveillance of these penetration seals from only one side is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.4.4 Gas Decay Tank Rooms (Rooms 692.0-A3 and 692.0-A5)

TVA stated that Rooms 692.0-A3 and 692.0-A5 are separated from adjacent non-high radiation area rooms by 2-and 3-hour fire rated barriers of reinforced concrete construction. TVA stated that the penetration seals are accessible for surveillance inspection from these adjacent rooms. The penetration seals are not accessible for inspection from the gas decay tank rooms due to the radiation posting of the rooms.

TVA stated that there is no safe shutdown equipment installed in the gas decay tank rooms, nor any equipment that could initiate a plant trip. FPR Part VI stated that the combustible loading in both rooms is insignificant. Additionally, TVA stated that all the adjacent rooms which contain cables or equipment needed for FSSD have installed automatic smoke detection.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited amount of combustibles in these rooms, the lack of safe shutdown equipment or cables in the gas decay tank rooms, the automatic smoke detection installed in the adjacent rooms that contain FSSD equipment or cables, and the ALARA concern identified by TVA, performing surveillance of these penetration seals from only one side is consistent with Interpretation 4, "Fire Area Boundaries," of NRC GL 86-10, and therefore, is acceptable.

6.3.4.5 Barriers between High Radiation Area Rooms (Rooms 676.0-A2, 676.0-A3, 692.0-A3 and 692.0-A5)

TVA stated that the barriers between Rooms 676.0-A2 and 676.0-A3, Rooms 676.0-A2 and 692.0-A3, and Rooms 692.0-A3 and 692.0-A5 are not accessible because of the high levels of radiation present in these rooms.

TVA stated that there is no safe shutdown equipment installed in any of these rooms, nor any equipment that could initiate a plant trip. FPR Part VI stated that the combustible loading in all the rooms is insignificant. Additionally, TVA stated that all the adjacent rooms which contain cables or equipment needed for FSSD have installed automatic smoke detection.

Based on its review of the information submitted by TVA, the NRC staff concludes that, because of the limited amount of combustibles in these rooms, the lack of safe shutdown equipment or cables in Rooms 676.0-A2, 676.0-A3, 692.0-A3 and 692.0-A5, the automatic smoke detection installed in the adjacent rooms which contain FSSD equipment or cables, and the ALARA concern identified by TVA, not performing surveillance of these penetration seals is consistent with Interpretation 4, "Fire Area Boundaries," of GL 86-10, and therefore, is acceptable.

6.3.5 Diesel Generator Building Lube Oil Storage Room Fire Doors

The lube oil storage room (Room 742.0-D2) is a 3-hour fire-rated compartment. The 3-hour fire rated doors are in the open position and close only when the thermal link above the door melts or the CO2 suppression system for the room discharges. To conform to the guidelines of NFPA 30 and 80, these doors should be self-closing. At each opening, TVA installed hollow metal side-hinged doors, which are normally closed. TVA stated that these doors are similar to rated fire doors and are expected to prevent smoke and hot gases from a fire from passing through the opening until the fusible links melt or the fire suppression system actuates.

Based on its review of the information submitted by TVA, the NRC staff concludes that the fire door configuration in the lube oil storage room complies with Position D.1.j of Appendix A to BTP (APCSB) 9.5-1 and, therefore, is acceptable.

7.0 CONCLUSION

On the basis of its review of TVA's as-designed FPR and TVA's supplemental information as referenced by this evaluation, the NRC staff concludes that the fire protection program for WBN, with the exception of Unit 1 specific OMAs, meets 10 CFR 50.48(a) and GDC 3 of Appendix A to 10 CFR Part 50, and is consistent with Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50 and Appendix A to BTP (APCSB) 9.5-1, May 1976, with properly justified deviations and exceptions. Therefore, the NRC staff finds the as-designed FPR acceptable, contingent on the completion of the confirmatory items identified in Section 8.0 of this evaluation (Open items 140, 141, 142, and 143, Appendix HH). NRC approval of the Unit 1 OMAs is documented in SSER 18, October 1995, of NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2."

U1 U2 U1 U2 U1

8.0 CONFIRMATORY ITEMS

#	Item Description
(140)	TVA to confirm to the NRC staff the completion of the Unit 2 OMA feasibility walkdowns.
(141)	TVA to confirm to the NRC staff the completion of the Multiple spurious operation scenario resolution actions for scenarios which only affect Unit 2.
(142)	TVA to confirm to the NRC staff the completion of the electrical coordination modifications.
(143)	TVA to confirm the as-built FPR aligns with as-designed FPR. Gaps to be submitted to the NRC for approval.

ENCLOSURE 6

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

SECTION 9.5.1 OF
SUPPLEMENTAL SAFETY EVALUATION REPORT 18 ANNOTATED

(Note that the layout of the text on the following pages of this enclosure depicts the text as it is in the SSER)

9.5 Other Auxiliary Systems

9.5.1 Fire Protection

In the SER, the staff discussed its review results of the Watts Bar fire protection program and fire hazards analysis submitted by the applicant on April 18, 1977; September 8, 1980; and August 28, 1981. Subsequently, the applicant relocated the fire protection information (via Amendment 87) from Section 9.5.1 of the FSAR and submitted the revised Watts Bar Fire Protection Report (FPR) by letters dated September 15, 1993 and its revisions dated November 18, 1994; April 27, 1995; June 15, 1995; and September 28, 1995.

The applicant initially revised its fire protection program report as a result of a comprehensive review under its fire protection corrective action program (see Section 1.13.1 of SSER 18). The principal program changes in Revision 0 are the removal of fire protection from the Technical Specifications (TSs) and documentation of the fire area reanalysis. The applicant undertook this reanalysis to take advantage of the compartmentation at Watts Bar and further subdivide the fire areas, and had described this reanalysis in the previous February 5, 1992, revision of the FPR. By letter dated June 2, 1993, the applicant described the revised fire areas. The applicant has incorporated this description into this revision of the FPR. This revision also reflects fire protection programmatic improvements and incorporates changes made in response to NRC comments. In this revision, the applicant states that its fire protection program has been developed to comply with, and is based on, the requirements of General Design Criterion 3 in Appendix A to 10 CFR 50.48, paragraphs (a) and (e), and the applicant's commitment to Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50, and Appendix A to Auxiliary Power Conversion Systems Branch (APCSB) Branch Technical Position (BTP) APCSB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to July 1, 1976." In addition, the applicant committed to meet the following NRC fire protection guidance: (1) NRC letter dated June 20, 1977, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance"; (2) Generic Letter (GL) 81-12, "Fire Protection Rule," and NRC memorandum of clarification to GL 81-12, dated March 22, 1982; (3) GL 82-21, "Technical Specifications for Fire Protection Audits"; (4) GL 83-33, "NRC Positions on Certain Requirements of Appendix R to 10 CFR 50"; (5) GL 86-10, "Implementation of Fire Protection Requirements"; and (7) GL 88-12, "Removal of Fire Protection Requirements from Technical Specifications."

The applicant has identified its revised Fire Protection Report as the document that describes the operational phase of the fire protection program and consolidates the regulatory fire protection program into a single document. Accordingly, the staff has re-reviewed the entire fire protection program, evaluating it against the NRC fire protection requirements and review guidance listed above. Because Watts Bar has two units of identical design (except as noted), this evaluation applies to the fire protection program for both units.

By letters of July 9, 1993; November 11, 1994; December 23, 1994; and March 29, 1995, the applicant submitted the results of its qualification testing of 1-hour Thermo-Lag 330-1 and 3-hour Thermo-Lag 770-1 electrical raceway fire barrier systems (ERFBSs). The staff has reviewed the applicant's fire endurance testing program, its acceptance criteria, and the test results against the fire barrier acceptance criteria guidance provided in GL 86-10, "Implementation of Fire Protection Requirements," and its supplement, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used To Separate Redundant Safe Shutdown Trains Within the Same Fire Area."

As a result of this review, the staff, in letters of December 2, 1992; April 6, 1994; December 14, 1994 (meeting summary by P. S. Tam, dated December 21, 1994); April 19, 1995; and May 10, 1995, requested additional information related to the adequacy of the proposed fire protection program. The applicant, in letters of February 10, 1993; November 26, 1993; July 1, 1994; January 27, 1995; and May 26, 1995, submitted the requested information to the staff for review and committed to make certain modifications to plant fire protection features and to the plant fire protection program and its implementation.

In addition, the staff met with the applicant on October 13, 1993 (summary by P. S. Tam, November 5, 1993); April 27, 1995 (summary by P. S. Tam, May 9, 1995); May 30, 1995 (site review notification by P. S. Tam, May 19, 1995); August 15, 1995 (summary by M. Bugg, August 30, 1995); and October 10, 1995 (summary by M. Bugg, October 13, 1995) to discuss technical issues related to Watts Bar's fire protection program and its implementation.

The staff's consultant, Brookhaven National Laboratory, participated in reviewing associated circuits and post-fire safe-shutdown capability and in preparing this safety evaluation, and concurs with the staff's findings.

Section 9.5.1 of the FSAR, currently updated to Amendment 91, incorporates the fire protection program by reference. Likewise, the staff's detailed evaluation of the revised fire protection program is moved from the text of this section, and is relocated in Appendix FF of this SSER. Since the applicant's original fire protection program, as evaluated in the SER, has been fully superseded by subsequent submittals as stated above, the open issues (identified as Outstanding Issue 12, Confirmatory Issue 38, and Proposed License Condition 20) are considered resolved.

On the basis of its review of the applicant's Fire Protection Report through Revision 4, and the applicant's supplemental information as referenced by this safety evaluation, the staff concludes that the fire protection program for Watts Bar Nuclear Plant conforms to the requirements of 10 CFR 50.48 and, except for (1) fire barrier penetration seal program (refer to Appendix FF, Section 3.1.4) and (2) emergency lighting inside the reactor building (refer to Appendix FF, Section 6.7), is acceptable. The staff will report resolution of these two issues in SSER 19.

The staff tracked its efforts by TAC M63648. The two open issues identified above will continue to be tracked by this TAC number.

ENCLOSURE 7

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

SECTION 9.5.1 OF
SUPPLEMENTAL SAFETY EVALUATION REPORT 26 ANNOTATED

(Note that the layout of the text on the following pages of this enclosure depicts the text as it is in the SSER)

9.5 Other Auxiliary Systems

9.5.1 Fire Protection

During the operating licensing review for Watts Bar Nuclear Plant (WBN) Unit 1, the NRC staff documented its review of the WBN fire protection program in Appendix FF of NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2," Supplemental Safety Evaluation Report (SSER) 18, issued October 1995, and SSER 19, issued November 1995. As part of the operating license application for WBN Unit 2, TVA submitted the As-Designed Fire Protection Report (FPR) for WBN Units 1 and 2 to the NRC by letter dated December 18, 2010, as revised and supplemented by letters dated December 20, 2010; January 14, March 16 and 31, May 6, 18, and 26, June 7 and 17, July 1 and 22, August 5 and 15, September 30, October 28, November 21 and 30, 2011; March 13, April 12, 17, and 26, May 9 and 30, June 7 and 27, July 19, September 13, December 20, 2012; February 7 and 28, and March 13, 2013. The NRC staff's detailed evaluation of the updated fire protection program appears in Appendix FF to this SSER. U1 U2

In the FPR, TVA stated that, "the purpose of the Fire Protection Report (FPR) is to consolidate a sufficiently detailed summary of the WBN regulatory required Fire Protection Program into a single document and to reflect the design as-constructed at the time of fuel load." The FPR describes the operational phase of the fire protection program. Accordingly, the NRC staff reviewed the entire fire protection program, except as noted below, using the agency's fire protection requirements and review guidance. Because WBN consists of two units of identical design, this evaluation applies to the fire protection program for both units, except as noted.

The NRC staff's review did not include Section 7, "Unit 1 Operator Manual Actions [OMAs]," of Part VII of the FPR. The NRC's approval of the WBN Unit 1 OMAs is documented in SSER 18. U1

In Staff Requirements Memorandum SECY-07-0096, "Possible Reactivation of Construction and Licensing Activities for the Watts Bar Nuclear Plant Unit 2," dated July 25, 2007, the Commission directed the NRC staff to use the existing WBN Unit 1 licensing basis as the reference basis for the WBN Unit 2 review. To that end, where applicable, the NRC staff used the WBN Unit 1 approvals, as documented in SSER 18 and 19, as the basis for its approvals in U2 this evaluation instead of the agency's current guidance. The NRC used its current guidance as the basis for approval for WBN Unit 2 OMA, associated circuits, multiple spurious operation, fire water system design demand, the auxiliary control room, and radiant energy shields.

The NRC staff met with TVA on January 19, February 3 and 15, March 29, April 22, May 12, June 30, July 12 and 28, August 31, November 16, and December 21, 2011; and February 2, 2012, to discuss technical issues related to WBN's fire protection program and its implementation. The NRC staff also conducted an audit at WBN from October 25-27, 2011, which was documented by a report dated December 20, 2011 (ADAMS Accession No. ML113500239).

Unless otherwise noted, all information cited in the evaluation found in Appendix FF is from the WBN FPR dated March 13, 2013 (ADAMS Accession No. ML130840169).

On the basis of its review of TVA's as-designed FPR and TVA's supplemental information as referenced by this evaluation, the NRC staff concludes that the fire protection program for WBN, with the exception of Unit 1 specific OMAs, meets 10 CFR 50.48(a) and GDC 3 of Appendix A to 10 CFR Part 50, and is consistent with Sections III.G, III.J, III.L, and III.O of Appendix R to 10 CFR Part 50 and Appendix A to BTP (APCSB) 9.5-1, May 1976, with properly justified deviations and exceptions. Therefore, the NRC staff finds the as-designed FPR acceptable, contingent on the completion of the confirmatory items identified in Section 8.0 of this evaluation **(Open items 140, 141, 142, and 143, Appendix HH)**. NRC approval of the Unit 1 OMAs is documented in SSER 18, October 1995, of NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2."

ENCLOSURE 8

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT
UNIT 1 AND UNIT 2

List of Regulatory Commitments

1. TVA plans to meet with the NRC staff in January 2014 to explain the SSER applicability tables and the supporting documentation for the tables. As part of this meeting, TVA will discuss with NRC the pending changes that need to be made to the as-designed two-unit report and establish a schedule for the submittal of the update which will include the new Part XI.