NUREG–0847
Supplement No. 18

Safety Evaluation Report

related to the operation of Watts Bar Nuclear Plant, Units 1 and 2

Docket Nos. 50–390 and 50–391

Tennessee Valley Authority

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

October 1995

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ABSTRACT

This report supplements the Safety Evaluation Report (SER), NUREG-0847 (June 1982), Supplement No. 1 (September 1982), Supplement No. 2 (January 1984), Supplement No. 3 (January 1985), Supplement No. 4 (March 1985), Supplement No. 5 (November 1990), Supplement No. 6 (April 1991), Supplement No. 7 (September 1991), Supplement No. 8 (January 1992), Supplement No. 9 (June 1992), Supplement No. 10 (October 1992), Supplement No. 11 (April 1993), Supplement No. 12 (October 1993), Supplement No. 13 (April 1994), Supplement No. 14 (December 1994), Supplement No. 15 (June 1995), Supplement No. 16 (September 1995), and Supplement No. 17 (October 1995) issued by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission with respect to the application filed by the Tennessee Valley Authority, as applicant and owner, for licenses to operate the Watts Bar Nuclear Plant, Units 1 and 2 (Docket Nos. 50-390 and 50-391). The facility is located in Rhea County, Tennessee, near the Watts Bar Dam on the Tennessee River. This supplement provides recent information regarding resolution of some of the outstanding and confirmatory items, and proposed license conditions identified in the SER.

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ABBREVIATIONS

AB	auxiliary building
ABGTS	auxiliary building gas treatment system
ACF	ampacity correction factor
ACR	auxiliary control room
AFW	auxiliary feedwater
ALARA	as low as reasonably achievable
APCSB	Auxiliary Power Conversion Systems Branch
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
ATI	acceptance test instruction
AV	analysis volume
AWG	American Wire Gauge
BIT	boron injection tank
BTP	branch technical position
CAM	continuous air monitor
CAP	Corrective Action Plan
CCRS	computerized cable routing system
CCS	component cooling system
CCTV	closed-circuit television
CCWS	component cooling water system
CFR	Code of Federal Regulations
CHF	critical heat flux
CLSD	Central Laboratories Services Department (TVA)
CNPP	Corporate Nuclear Performance Plan
CPU	central processor unit
CRVS	control room ventilation system
CST	condensate storage tank
CT	component test
DCRDR	detailed control room design review
DG	diesel generator
DNB	departure from nucleate boiling
DNBR	departure-from-nucleate-boiling ratio
ECCS	emergency core cooling system
EOP	emergency operating procedure
ERCW	essential raw cooling water
ERFBS	electrical raceway fire barrier system
ERFDS	emergency response facility data system
FM	Factory Mutual
FPR	Fire Protection Report
FHA	fire hazards analysis
FSAR	final safety analysis report
GDC	general design criterion
GL	generic letter
HED	human engineering deficiency

HEPA	high efficiency particulate air
HIF	high-impedance fault
HVAC	heating, ventilation, and air conditioning
ICEA	Insulated Cable Engineers Association
IE	Office of Inspection and Enforcement
IEEE	Institute of Electrical and Electronics Engineers
IPS	intake pumping station
IR	infrared
IST	inservice test
ITP	Initial Test Program
JB	junction box
LB	lateral bend
LCO	limiting condition for operation
LOCA	loss-of-coolant accident
LS	lateral side
MCC	motor control center
MCR	main control room
MHIFs	multiple high-impedance faults
MIC	microbiologically induced corrosion
NFPA	National Fire Protection Association
NRC	Nuclear Regulatory Commission
NSRB	Nuclear Safety Review Board
NSSS	nuclear steam supply system
OBE	operating basis earthquake
OD	outside diameter
OPL	Omega Point Laboratories
PASS	postaccident sampling system
PECO	Philadelphia Electric Co.
PIV	post-indicator-type valve
PORC	Plant Operations Review Committee
PORV	pilot/power-operated relief valve
PSRV	pressurizer safety/relief valve
QA	quality assurance
QC	quality control
RAI	request for additional information
RCP	reactor coolany pump
RCS	reactor coolant system
RG	regulatory guide
RHR	residual heat removal
RRSs	required response spectra
RTD	resistance temperature detector
RWST	refueling water storage tank
SDB	shutdown board
SER	safety evaluation report
SP	special program
SPT	special performance test

SRP	standard review plan
SSE	safe-shutdown earthquake
SSER	supplement to safety evaluation report
SSI	soil-structurw interaction
STSs	Standard Technical Specifications
SWS	service water system
TAC	technical assignment control
TC	thermocouple
TGV	thermogravimetric analysis
TI	temporary instruction
3M	Minnesota Mining and Manufacturing
TSs	technical specifications
TSI	Thermal Science, Incorporated
TUE	Texas Utilities Electric
TVA	Tennessee Valley Authority
UL	Underwriters Laboratories, Inc.
VCT	volume control tank
VHF	very high frequency
VPA	ventilation and purge area
WBNPP	Watts Bar Nuclear Performance Plan
WISP	Workload Information and Scheduling Program
WOG	Westinghouse Owners Group

1 INTRODUCTION AND DISCUSSION

1.1 Introduction

In June 1982, the Nuclear Regulatory Commission staff (NRC staff or staff) issued a Safety Evaluation Report, NUREG-0847, regarding the application by the Tennessee Valley Authority (TVA or the applicant) for licenses to operate the Watts Bar Nuclear Plant, Units 1 and 2. The Safety Evaluation Report (SER) was followed by SER Supplement No. 1 (SSER 1, September 1982), Supplement No. 2 (SSER 2, January 1984), Supplement No. 3 (SSER 3, January 1985), Supplement No. 4 (SSER 4, March 1985), Supplement No. 5 (SSER 5, November 1990), Supplement No. 6 (SSER 6, April 1991), Supplement No. 7 (SSER 7, September 1991), Supplement No. 8 (SSER 8, January 1992), Supplement No. 9 (SSER 9, June 1992), Supplement No. 10 (SSER 10, October 1992), Supplement No. 11 (SSER 11, April 1993), Supplement No. 12 (October 1993), Supplement No. 13 (SSER 13, April 1994), Supplement No. 14 (SSER 14, December 1994), Supplement No. 15 (SSER 15, June 1995), Supplement 16 (SSER 16, September 1995), and Supplement No. 17 (SSER 17, October 1995). The staff has completed its review of the applicant's Final Safety Analysis Report (FSAR) up to Amendment 90.

The SER and its supplements were written to agree with the format and scope outlined in the Standard Review Plan (SRP, NUREG-0800). Issues raised by the SRP review that were not closed out when the SER was published were classified into outstanding issues, confirmatory issues, and proposed license conditions (see Sections 1.7, 1.8, and 1.9, respectively, which follow).

In addition to the guidance in the SRP, the staff issues generic requirements or recommendations in the form of technical reports, bulletins, and generic letters. Each of these documents carries its own applicability, work scope, and acceptance criteria; some are applicable to Watts Bar. The review and implementation status of applicable generic issues are addressed in Appendix EE of SSER 16.

Each of the following sections and appendices of this supplement is numbered the same as the section or appendix of the SER that is being updated, and the discussions are supplementary to, and not in lieu of, the discussion in the SER, unless otherwise noted. Accordingly, Appendix A continues the chronology of the safety review. Appendix E lists principal contributors to this supplement. Appendix FF is added in this supplement. The other appendices are not changed by this supplement.

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1.7 Summary of Outstanding Issues

In SER Section 1.7, the staff listed 17 outstanding issues (open items) that had not been resolved at the time the SER was issued. Additional outstanding issues were added in SER supplements that followed. In this section, the staff updates the status of those items. The completion status of each of the issues is tabulated below with the relevant document in which the issue was last addressed shown in parentheses. Detailed, up-to-date status information for still-unresolved issues is conveyed in the staff's summaries of the licensing status meetings.

Issue[1]	Status	Section
(1) Potential for liquefaction beneath ERCW pipelines and Class 1E electrical conduit	Resolved (SSER 3)	2.5.4.4
(2) Buckling loads on Class 2 and 3 supports	Resolved (SSER 4)	3.9.3.4
(3) Inservice pump and valve test program (TACs M74801, M92773)	Resolved (SSERs 14 and 18)	3.9.6
(4) Qualification of equipment		
(a) Seismic (TAC M71919)	Resolved (SSER 9)	3.10
(b) Environmental (TAC M63591)	Resolved (SSER 15)	3.11
(5) Preservice inspection program (TAC M63627, M86037, M93313)	Resolved for Unit 1 (SSERs 10, 12, 16)	5.2.4, 6.6, App. Z
(6) Pressure-temperature limits for Unit 2 only	On hold (SER)	5.3.2, 5.3.3
(7) Model D-3 steam generator preheater tube degradation	Resolved (SSER 4)	5.4.2.2
(8) Branch Technical Position CSB 6-4	Resolved (SSER 3)	6.2.4
(9) H_2 analysis review	Resolved (SSER 4)	6.2.5
(10) Safety valve sizing analysis (WCAP-7769)	Resolved (SSER 2)	5.2.2
(11) Compliance of proposed design change to the offsite power system to GDCs 17 and 18 (TAC M63649)	Resolved (SSER 13)	8.2
(12) Fire-protection program (TAC M63648)	Resolved (SSER 18)	9.5.1

[1]The TAC (technical assignment control) numbers that appear in parentheses after some issue titles and elsewhere in this document, are internal NRC control numbers by which the issue is managed through the Workload Information and Scheduling Program (WISP) and by which relevant documents are filed. Documents associated with each TAC number can be located by the NRC document control system, NUDOCS/AD.

Issue	Status	Section
(13) Quality classification of diesel generator auxiliary system piping and components (TAC M63638)	Resolved (SSER 5)	9.5.4.1
(14) Diesel generator auxiliary system design deficiencies (TAC M63638)	Resolved (SSER 5)	9.5.4, 9.5.5, 9.5.7
(15) Physical Security Plan (TAC M63657)	Resolved (SSER 15)	13.6
(16) Boron-dilution event	Resolved (SSER 4)	15.2.4.4
(17) QA Program (TAC M76972)	Resolved (SSER 13)	17
(18) Seismic classification of cable trays and conduit (TACs R00508, R00516)	Resolved (SSER 8)	3.2.1, 3.10
(19) Seismic design concerns (TACs M79717, M80346):		
(a) Number of OBE events	Resolved (SSER 8)	3.7.3
(b) 1.2 multi-mode factor	Resolved (SSER 9)	3.7.3
(c) Code usage	Resolved (SSER 8)	3.7.3
(d) Conduit damping values	Resolved (SSER 8)	3.7.3
(e) Worst case, critical case, bounding calculations	Resolved (SSER 12)	3.7.3
(f) Mass eccentricities	Resolved (SSER 8)	3.7.2.1.2
(g) Comparison of set A versus set B response	Resolved (SSER 11)	3.7.2.12
(h) Category 1(L) piping qualification	Resolved (SSER 8)	3.9.3
(i) Pressure relief devices	Resolved (SSER 7)	3.9.3.3
(j) Structural issues	Resolved (SSER 9)	3.8
(k) Update FSAR per 12/18/90 letter	Resolved (SSER 8)	3.7
(20) Mechanical systems and components (TACs M79718, M80345)		
(a) Feedwater check valve slam	Resolved (SSER 13)	3.9.1
(b) New support stiffness and deflection limits	Resolved (SSER 8)	3.9.3.4
(21) Removal of RTD bypass system (TAC M63599)	Resolved (SSER 8)	4.4.3
(22) Removal of upper head injection system (TAC M77195)	Resolved (SSER 7)	6.3.1
(23) Containment isolation using closed systems (TAC M63597)	Resolved (SSER 12)	6.2.4
(24) Main steamline break outside containment (TAC M63632)	Resolved (SSER 14)	3.6.1

Issue	Status	Section
(25) Health Physics Program (TAC M63647)	Resolved (SSER 10)	12
(26) Regulatory Guide 1.97, Instruments To Follow Course of Accident (TACs M77550, M77551)	Resolved (SSER 9)	7.5.2
(27) Containment sump screen design anomalies (TAC M77845)	Resolved (SSER 9)	6.3.3
(28) Emergency procedure (TAC M77861)	Resolved (SSER 9)	13.5.2.1

1.8 Summary of Confirmatory Issues

In SER Section 1.8, the staff listed 42 confirmatory issues for which additional information and documentation were required to confirm preliminary conclusions. Issue 43 was added in SSER 6. In this section, the staff updates the status of those items for which the confirmatory information has subsequently been provided by the applicant and for which review has been completed by the staff. The completion status of each of the issues is tabulated below, with the relevant document in which the issue was last addressed shown in parentheses.

Issue	Status	Section
(1) Design-basis groundwater level for the ERCW pipeline	Resolved (SSER 3)	2.4.8
(2) Material and geometric damping effect in SSI analysis	Resolved (SSER 3)	2.5.4.2
(3) Analysis of sheetpile walls	Resolved (SSER 3)	2.5.4.2
(4) Design differential settlement of piping and electrical components between rock-supported structures	Resolved (SSER 3)	2.5.4.3
(5) Upgrading ERCW system to seismic Category I (TAC M63617)	Resolved (SSER 5)	3.2.1, 3.2.2
(6) Seismic classification of structures, systems, and components important to safety (TAC M63618)	Resolved (SSER 5)	3.2.1
(7) Tornado-missile protection of diesel generator exhaust	Resolved (SSER 2)	3.5.2, 9.5.4.1, 9.5.8
(8) Steel containment building buckling research program	Resolved (SSER 3)	3.8.1
(9) Pipe support baseplate flexibility and its effects on anchor bolt loads (IE Bulletin 79-02) (TAC M63625)	Resolved (SSER 8)	3.9.3.4

Issue	Status	Section
(10) Thermal performance analysis	Resolved (SSER 2)	4.2.2
(11) Cladding collapse	Resolved (SSER 2)	4.2.2
(12) Fuel rod bowing evaluation	Resolved (SSER 2)	4.2.3
(13) Loose-parts monitoring system	Resolved (SSER 3)	4.4.5
(14) Installation of residual heat removal flow alarm	Resolved (SSER 5)	5.4.3
(15) Natural circulation tests (TACs M63603, M79317, M79318)	Resolved (SSER 10)	5.4.3
(16) Atmospheric dump valve testing	Resolved (SSER 2)	5.4.3
(17) Protection against damage to containment from external pressure	Resolved (SSER 3)	6.2.1.1
(18) Designation of containment isolation valves for main and auxiliary feedwater lines and feedwater bypass lines (TAC M63623)	Resolved (SSER 5)	6.2.4
(19) Compliance with GDC 51	Resolved (SSER 4)	6.2.7, App. H
(20) Insulation survey (sump debris)	Resolved (SSER 2)	6.3.3
(21) Safety system setpoint methodology	Resolved (SSER 4)	7.1.3.1
(22) Steam generator water level reference leg	Resolved (SSER 2)	7.2.5.9
(23) Containment sump level measurement	Resolved (SSER 2)	7.3.2
(24) IE Bulletin 80-06	Resolved (SSER 3)	7.3.5
(25) Overpressure protection during low-temperature operation	Resolved (SSER 4)	7.6.5
(26) Availability of offsite circuits	Resolved (SSER 2)	8.2.2.1
(27) Non-safety loads powered from the Class 1E ac distribution system	Resolved (SSER 2)	8.3.1.1
(28) Low and/or degraded grid voltage condition (TAC M63649)	Resolved (SSER 13)	8.3.1.2
(29) Diesel generator reliability qualification testing (TAC M63649)	Resolved (SSER 7)	8.3.1.6
(30) Diesel generator battery system	Resolved (SSER 2)	8.3.2.4

Issue	Status	Section
(31) Thermal overload protective bypass	Resolved (SSER 2)	8.3.3.1.2
(32) Update FSAR on sharing of dc and ac distribution systems (TAC M63649)	Resolved (SSER 13)	8.3.3.2.2
(33) Sharing of raceway systems between units	Resolved (SSER 2)	8.3.3.2
(34) Testing Class 1E power systems	Resolved (SSER 2)	8.3.3.5.2
(35) Evaluation of penetration's capability to withstand failure of overcurrent protection device (TAC M63649)	Resolved (SSER 7)	8.3.3.6
(36) Missile protection for diesel generator vent line (TAC M63639)	Resolved (SSER 5)	9.5.4.2
(37) Component cooling booster pump relocation	Resolved (SSER 5)	9.2.2
(38) Electrical penetrations documentation (TAC M63648)	Resolved (SSER 18)	9.5.1.3
(39) Compliance with NUREG/CR-0660 (TAC M63639)	Resolved (SSER 5)	9.5.4.1
(40) No-load, low-load, and testing operations for diesel generator (TAC M63639)	Resolved (SSER 5)	9.5.4.1
(41) Initial test program	Resolved (SSER 3)	14
(42) Submergence of electrical equipment as result of a LOCA (TAC M63649)	Resolved (SSER 13)	8.3.3.1.1
(43) Safety parameter display system (TAC M73723)	Resolved (SSER 15)	18.2

1.9 Summary of Proposed License Conditions

In Section 1.9 of the SER and in SSERs that followed, the staff listed 43 proposed license conditions. Since these documents were issued, the applicant has submitted additional information on some of these items, thereby removing the necessity to impose a condition. The completion status of the proposed license conditions is tabulated below, with the relevant document in which the issue was last addressed shown in parentheses. Detailed, up-to-date status of still-unresolved issues is conveyed in the staff's summaries of the licensing status meetings.

Proposed Condition	Status	Section
(1) Relief and safety valve testing (II.D.1)	Resolved (SSER 3)	3.9.3.3, 5.2.2

Proposed Condition	Status	Section
(2) Inservice testing of pumps and valves (TAC M74801)	Resolved (SSER 12)	3.9.6
(3) Detectors for inadequate core cooling (II.F.2) (TACs M77132, M77133)	Resolved (SSER 10)	4.4.8
(4) Inservice Inspection Program (TAC M76881)	Resolved (SSER 12)	5.2.4, 6.6
(5) Installation of reactor coolant vents (II.B.1)	Resolved (SSER 5)	5.4.5
(6) Accident monitoring instrumentation (II.F.1)		
(a) Noble gas monitor (TAC M63645)	Resolved (SSER 5)	11.7.1
(b) Iodine particulate sampling (TAC M63645)	Resolved (SSER 6)	11.7.1
(c) High-range in-containment radiation monitor (TAC M63645)	Resolved (SSER 5)	12.7.2
(d) Containment pressure	Resolved (SSER 5)	6.2.1
(e) Containment water level	Resolved (SSER 5)	6.2.1
(f) Containment hydrogen	Resolved (SSER 5)	6.2.5
(7) Modification to chemical feedlines (TAC M63622)	Resolved (SSER 5)	6.2.4
(8) Containment isolation dependability (II.E.4.2) (TAC M63633)	Resolved (SSER 5)	6.2.4
(9) Hydrogen control measures (NUREG-0694, II.B.7) (TAC M77208)	Resolved (SSER 8)	6.2.5, App. C
(10) Status monitoring system/BISI (TACs M77136, M77137)	Resolved (SSER 7)	7.7.2
(11) Installation of acoustic monitoring system (II.D.3)	Resolved (SSER 5)	7.8.1
(12) Diesel generator reliability qualification testing at normal operating temperature	Resolved (SSER 2)	8.3.1.6
(13) DC monitoring and annunciation (TAC M63649)	Resolved (SSER 13)	8.3.2.2
(14) Possible sharing of dc control power to ac switchgear	Resolved (SSER 3)	8.3.3.2.4
(15) Testing of associated circuits	Resolved (SSER 3)	8.3.3.3
(16) Testing of non-Class 1E cables	Resolved (SSER 3)	8.3.3.3

Proposed Condition	Status	Section
(17) Low-temperature overpressure protection/power supplies for pressurizer relief valves and level indicators (II.G.1) (TAC M63649)	Resolved (SSER 7)	8.3.3.4
(18) Testing of reactor coolant pump breakers	Resolved (SSER 2)	8.3.3.6
(19) Postaccident sampling system (TAC M77543)	Resolved (SSER 14)	9.3.2
(20) Fire protection program (TAC M63648)	Resolved (SSER 18)	9.5.1.8
(21) Performance testing for communications systems (TAC M63637)	Resolved (SSER 5)	9.5.2
(22) Diesel generator reliability (NUREG/CR-0660) (TAC M63640)	Resolved (SSER 5)	9.5.4.1
(23) Secondary water chemistry monitoring and control program	Resolved (SSER 5)	10.3.4
(24) Primary coolant outside containment (III.D.1.1) (TACs M63646, M77553)	Resolved (SSER 10)	11.7.2
(25) Independent safety engineering group (I.B.1.2) (TAC M63592)	Resolved (SSER 8)	13.4
(26) Use of experienced personnel during startup (TAC M63592)	Resolved (SSER 8)	13.1.3
(27) Emergency preparedness (III.A.1.1, III.A.1.2, III.A.2) (TAC M63656)	Resolved (SSER 13)	13.3
(28) Review of power ascension test procedures and emergency operating procedures by NSSS vendor (I.C.7) (TAC M77861)	Resolved (SSER 10)	13.5.2
(29) Modifications to emergency operating instructions (I.C.8) (TAC M77861)	Resolved (SSER 10)	13.5.2
(30) Report on outage of emergency core cooling system (II.K.3.17)	Resolved (SSER 3)	13.5.3
(31) Initial test program (TAC M79872)	Resolved (SSER 7)	14.2
(32) Effect of high-pressure injection for small-break LOCA with no auxiliary feedwater (II.K.2.13)	Resolved (SSER 4)	15.5.1

Proposed Condition	Status	Section
(33) Voiding in the reactor coolant system (II.K.2.17)	Resolved (SSER 4)	15.5.2
(34) PORV isolation system (II.K.3.1, II.K.3.2) (TAC M63631)	Resolved (SSER 5)	15.5.3
(35) Automatic trip of the reactor coolant pumps during a small-break LOCA (II.K.3.5)	Resolved (SSER 4)	15.5.4
(36) Revised small-break LOCA analysis (II.K.3.30, II.K.3.31) (TAC M77298)	Resolved (SSER 5)	15.5.5
(37) Detailed control room design review (I.D.1) (TAC M63655)	Resolved (SSER 15)	18.1
(38) Physical security of fuel in containment (TACs M63657, M83973)	Resolved (SSER 10)	13.6.4
(39) Control of heavy loads (NUREG-0612) (TAC M77560)	Resolved (SSER 13)	9.1.4
(40) Anticipated transients without scram (Generic Letter 83-28, Item 4.3) (TAC M64347)	Resolved (SSER 5)	15.3.6
(41) Steam generator tube rupture (TAC M77569)	Resolved (SSER 14)	15.4.3
(42) Loose-parts monitoring system (TAC M77177)	Resolved (SSER 5)	4.4.5
(43) Safety parameter display system (TAC M73723)	Opened (SSER 5)	18.2
(44) Physical Security Plan (TACs M63657, M83973)	Opened (SSER 15)	13.6

1.12 Approved Technical Issues for Incorporation in the License as Exemptions

The applicant applied for exemptions from certain provisions of the regulations. These have been reviewed by the staff and approved in appropriate sections of the SER and SSERs. These technical issues are listed below and the actual exemptions will be incorporated in the operating license:

(1) Seal leakage test instead of full-pressure test (Section 6.2.6, SSER 4) (TAC M63615)

(2) Criticality monitor (Section 9.1, SSER 5) (TAC M63615)

(3) Schedule to implement the vehicle bomb rule (Section 13.6.9, SSER 15) (TAC M90696)

In addition to these, the staff granted the following two exemptions to the applicant on December 15, 1994, and October 17, 1995, respectively:

(4) Issuance, storage, and retrieval of badges for personnel (TAC M90729)

(5) Participation by States within the ingestion exposure pathway emergency planning zone in the emergency preparedness exercise (TAC M92943)

In SSER 14, the staff reevaluated three technical issues previously approved for exemption from various provisions of Appendix G to 10 CFR Part 50. As a result, Section 5.3.1.1 of SSER 14 reports that these exemptions are no longer needed.

1.13 Implementation of Corrective Action Programs and Special Programs

On September 17, 1985, the NRC sent a letter to the applicant, pursuant to Title 10 of the Code of Federal Regulations, Section 50.54(f), requesting that the applicant submit information on its plans for correcting problems concerning the overall management of its nuclear program as well as on its plans for correcting plant-specific problems. In response to this letter, TVA prepared a Corporate Nuclear Performance Plan (CNPP) that identified and proposed corrections to problems concerning the overall management of its nuclear program, and a site-specific plan for Watts Bar entitled "Watts Bar Nuclear Performance Plan" (WBNPP). The staff reviewed both plans and documented results in two safety evaluation reports, NUREG-1232, Vol. 1 (July 1987), and NUREG-1232, Vol. 4 (January 1990).

In a letter of September 6, 1991, the applicant submitted Revision 1 of the WBNPP. In SSER 9, the staff concluded that Revision 1 of the WBNPP does not necessitate any revision of the staff's safety evaluation report, NUREG-1232, Vol. 4.

In NUREG-1232, Vol. 4, the staff documented its general review of the corrective action programs (CAPs) and special programs (SPs) through which the applicant would effect corrective actions at Watts Bar. When the report was published, some of the CAPs and SPs were in their initial stages of implementation. The staff stated that it will report its review of the implementation of all CAPs and SPs and closeout of open issues in future supplements to the licensing SER, NUREG-0847; accordingly, the staff prepared Temporary Instructions (TIs) 2512/016-043 for the Inspection Manual and adhered to the TIs to perform inspections of the CAPs and SPs. This new section was introduced in SSER 5 to be updated in subsequent SSERs. The current status of all CAPs and SPs follows. The status described here fully supersedes that described in previous SSERs.

1.13.1 Corrective Action Programs

(1) Cable Issues (TAC M71917; TI 2512/016)

Program review status: Complete: NUREG-1232, Vol. 4; Letter, P. S. Tam (NRC) to D. A. Nauman (TVA), April 25, 1991 (the safety evaluation was reproduced in SSER 7 as Appendix P); supplemental safety evaluation dated April 24, 1992 (Appendix T of SSER 9); letter, P. S. Tam (NRC) to M. O. Medford (TVA), February 14, 1994.

Implementation status:	Full implementation expected by October 1995.
NRC inspections:	Inspection Reports 50-390, 391/90-09 (June 22, 1990); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/90-22 (November 21, 1990); 50-390, 391/90-24 (December 17, 1990); 50-390, 391/90-27 (December 20, 1990); 50-390, 391/90-30 (February 25, 1991); 50-390, 391/91-07 (May 31, 1991); 50-390, 391/91-09 (July 15, 1991); 50-390, 391/91-12 (July 12, 1991); 50-390, 391/91-31 (January 13, 1992); 50-390, 391/92-01 (March 17, 1992); audit report of June 12, 1992 (Appendix Y of SSER 9); 50-390, 391/92-05 (April 17, 1992); 50-390, 391/92-13 (July 16, 1992); 50-390, 391/92-18 (August 14, 1992); 50-390, 391/92-22 (September 18, 1992); 50-390, 391/92-26 (October 16, 1992); 50-390, 391/92-30 (November 13, 1992); 50-390, 391/92-35 (December 15, 1992); 50-390, 391/92-40 (January 15, 1993); 50-390, 391/93-10 (March 19, 1993); 50-390, 391/93-11 (March 25, 1993); 50-390, 391/93-35 (June 10, 1993); 50-390, 391/93-40 (July 15, 1993); 50-390, 391/93-48 (August 13, 1993); 50-390, 391/93-56 (September 20, 1993); 50-390, 391/93-63 (October 18, 1993); 50-390, 391/93-70 (November 12, 1993); 50-390, 391/93-74 (December 20, 1993); 50-390, 391/93-85 (January 14, 1994); 50-390, 391/93-91 (February 17, 1994); 50-390, 391/94-11 (March 16, 1994); 50-390, 391/94-18 (April 18, 1994); 50-390, 391/94-32 (May 16, 1994); 50-390, 391/94-35 (June 20, 1994); 50-390, 391/94-45 (July 15, 1994); 50-390, 391/94-51 (August 11, 1994); 50-390, 391/94-53 (September 20, 1994); 50-390, 391/94-55 (September 16, 1994); 50-390, 391/94-61 (October 12, 1994); 50-390, 391/94-66 (November 16, 1994); 50-390, 391/94-75 (December 19, 1994); 50-390, 391/94-82 (January 13, 1995); 50-390, 391/94-88 (February 15, 1995); 50-390, 391/95-17 (April 13, 1995); 50-390, 391/95-45 (August 15, 1995); 50-390, 391/95-57 (September 15, 1995); 50-390, 391/95-64 (October 11, 1995); to come.

(2) <u>Cable Tray and Tray Supports (TAC R00516; TI 2512/017)</u>

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 13, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.
Implementation status:	Full implementation expected by October 1995.
NRC inspections:	Inspection Reports 50-390, 391/89-14 (December 18, 1989); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/90-22 (November 21, 1990); 50-390, 391/92-02 (March 17, 1992); audit report of May 14, 1992 (Appendix S of SSER 9); 50-390, 391/92-13 (July 16, 1992); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/93-07 (February 19, 1993); 50-

390/94-64 (December 15, 1994); 50-390, 391/94-88 (February 15, 1995); 50-390, 391/95-23 (May 2, 1995); 50-390, 391/95-27 (May 31, 1995); 50-390, 391/95-35 (June 28, 1995); to come.

(3) <u>Design Baseline and Verification Program (TAC M63594; TI 2512/019)</u>

Program review status:	Complete: Inspection Report 50-390, 391/89-12 (November 20, 1989); NUREG-1232, Vol. 4; Inspection Report 50-390/95-36 (June 21, 1995).
Implementation status:	100% (certified by letter, R. R. Baron (TVA) to NRC, September 27, 1995).
NRC inspections:	Complete: Inspection Reports 50-390, 391/89-12 (November 20, 1989); 50-390, 391/90-09 (June 22, 1990); 50-390, 391/90-20; (September 25, 1990); 50-390/91-201 (March 22, 1991); 50-390, 391/91-20 (October 8, 1991); 50-390, 391/91-25 (December 13, 1991); 50390, 391/92-06 (April 3, 1992); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/93-29 (May 14, 1993); 50-390, 391/93-66 (October 29, 1993); 50-390, 391/94-69 (November 18, 1994); 50-390/95-36 (June 21, 1995); 50-390, 391/95-47 (August 16, 1995).

(4) <u>Electrical Conduit and Conduit Support (TAC R00508; TI 2512/018)</u>

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 1, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.
Implementation status:	Full implementation expected by October 1995.
NRC inspections:	Inspection Reports 50-390, 391/89-05 (May 25, 1989); 50-390, 391/89-07; (July 11, 1989); 50-390, 391/89-14 (December 18, 1989); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/91-31 (January 13, 1992); 50-390, 391/92-02 (March 17, 1992); audit report of May 14, 1992 (Appendix S of SSER 9); 50-390, 391/92-05 (April 17, 1992); 50-390, 391/92-09 (June 29, 1992); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/92-26 (October 16, 1992); 50-390, 391/93-07 (February 19, 1993); 50-390, 391/93-35 (June 10, 1993); 50-390, 391/93-70 (November 12, 1993); 50-390, 391/93-74 (December 20, 1993); 50-390, 391/93-91 (February 17, 1994); 50-390, 391/94-11 (March 16, 1994); 50-390, 391/94-32 (May 16, 1994); 50-390/94-64 (December 15, 1994); 50-390, 391/94-82 (January 13, 1995); 50-390, 391/94-88 (February 15, 1995); 50-390, 391/95-23 (May 2, 1995); 50-390, 391/95-27 (May 31, 1995); 50-390, 391/95-35 (June 28, 1995); 50-390, 391/95-57 (September 15, 1995); to come.

(5) Electrical Issues (TAC M74502; TI 2512/020)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 11, 1989; NUREG-1232, Vol. 4.
Implementation status:	Full implementation expected by October 1995.
NRC inspections:	Inspection Reports 50-390, 391/90-30 (February 25, 1991); 50-390, 391/92-22 (September 18, 1992); 50-390, 391/92-40 (January 15, 1993); 50-390, 391/93-35 (June 10, 1993); 50-390, 391/93-40 (July 15, 1993); 50-390, 391/93-63 (October 18, 1993); 50-390, 391/94-11 (March 16, 1994); 50-390, 391/94-18 (April 18, 1994); 50-390, 391/94-31 (May 11, 1994); 50-390, 391/94-45 (July 15, 1994); 50-390, 391/94-53 (September 20, 1994); 50-390, 391/94-66 (November 16, 1994); 50-390, 391/94-82 (January 13, 1995); 50-390, 391/94-88 (February 15, 1995); 50-390, 391/95-57 (September 15, 1995); 50-390, 391/95-64 (October 11, 1995); to come.

(6) Equipment Seismic Qualification (TAC M71919; TI 2512/021)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 11, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.10.
Implementation status:	100%.
NRC inspections:	Complete: Inspection Reports 50-390, 391/90-05 (May 10, 1990); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/90-28 (January 11, 1991); 50-390, 391/91-03 (April 15, 1991); audit report of May 14, 1992 (Appendix S of SSER 9); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/93-07 (February 19, 1993); 50-390, 391/93-79 (March 4, 1994); 50-390, 391/95-30 (June 22, 1995); 50-390, 391/95-55 (August 28, 1995).

(7) Fire Protection (TAC M63648; TI 2512/022)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 7, 1989; NUREG-1232, Vol. 4; SSER 18, Section 9.5.1 and Appendix FF.
Implementation status:	100%; staff concurrence in Inspection Report 50-390, 391/95-61, October 5, 1995.
NRC inspections:	Complete: Inspection Reports 50-390, 391/94-45 (July 15, 1994); 50-390, 391/94-63 (November 2, 1994); 50-390, 391/94-62 (November 16, 1994); 50-390, 391/94-66 (November 16, 1994); 50-390, 391/94-78 (December 21, 1994); 50-390, 391/94-82 (January 13, 1995); 50-390, 391/95-03 (January 31, 1995); 50-390, 391/95-13 (March 1, 1995); 50-390, 391/95-

16 (April 6, 1995); 50-390, 391/95-26 (May 1, 1995); 50-390, 391/95-32 (June 9, 1995); 50-390, 391/95-39 (July 18, 1995); 50-390, 391/95-40 (September 12, 1995); 50-390, 391/95-61 (October 5, 1995).

(8) Hanger and Analysis Update Program (TAC R00512; TI 2512/023)

Program review status: Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), October 6, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.

Implementation status: 100%; staff concurrence in Inspection Report 50-390, 391/95-53, September 8, 1995.

NRC inspections: Complete: Inspection Reports 50-390, 391/89-14 (December 18, 1989); 50-390, 391/90-14 (August 3, 1990); 50-390, 391/90-18 (September 20, 1990); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/90-28 (January 11, 1991); 50-390, 391/91-03 (April 15, 1991); audit report of May 14, 1992 (Appendix S of SSER 9); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/92-26 (October 16, 1992); 50-390, 391/92-35 (December 15, 1992); 50-390, 391/93-07 (February 19, 1993); 50-390, 391/93-35 (June 10, 1993); 50-390, 391/93-45 (July 20, 1993); 50-390, 391/93-56 (September 20, 1993); 50-390, 391/93-70 (November 12, 1993); 50-390, 391/93-74 (December 20, 1993); 50-390, 391/94-11 (March 16, 1994); 50-390, 391/94-32 (May 16, 1994); 50-390, 391/94-55 (September 16, 1994); 50-390, 391/95-06 (March 16, 1995); 50-390, 391/95-23 (May 2, 1995); 50-390, 391/95-27 (May 31, 1995); 50-390, 391/95-35 (June 28, 1995); 50-390, 391/95-53 (September 8, 1995).

(9) Heat Code Traceability (TAC M71920; TI 2512/024)

Program review status: Complete: Inspection Report 50-390, 391/89-09 (September 20, 1989); NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to D. A. Nauman (TVA), March 29, 1991.

Implementation status: 100% (certified by letter, E. Wallace (TVA) to NRC, July 31, 1990); staff concurrence in SSER 7, Section 3.2.2.

NRC inspections: Complete: Inspection Reports 50-390, 391/89-09 (September 20, 1989); 50-390, 391/90-02 (March 15, 1990).

(10) Heating, Ventilation, and Air-Conditioning Duct and Duct Supports (TAC R00510; TI 2512/025)

Program review status: Complete: Letter, S. C. Black (NRC) to O. D.

	Kingsley (TVA), October 24, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.
Implementation status:	100% (certified by letter, R. R. Baron to NRC, October 10, 1995); staff concurrence in Inspection Report 50-390, 391/95-46, August 1, 1995.
NRC inspections:	Complete: Inspection Reports 50-390, 391/89-14 (December 18, 1989); 50-390, 391/90-05 (May 10, 1990); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/91-01 (April 4, 1991); 50-390, 391/92-02 (March 17, 1992); audit report of May 14, 1992 (Appendix S of SSER 9); 50-390, 391/92-08 (May 15, 1992); 50-390, 391/92-13 (July 16, 1992); 50-390, 391/92-201 (September 21, 1992); 50-390, 391/93-07 (February 19, 1993); 50-390, 391/93-91 (February 17, 1994); 50-390, 391/94-08 (March 11, 1994); 50-390, 391/95-23 (May 2, 1995); 50-390, 391/95-35 (June 28, 1995); 50-390, 391/95-46 (August 1, 1995).

(11) Instrument Lines (TAC M71918; TI 2512/026)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 8, 1989; NUREG-1232, Vol. 4; Appendix K of SSER 6; letter, P. S. Tam (NRC) to O. D. Kingsley (TVA), May 5, 1994.
Implementation status:	100%; staff concurrence in Inspection Report 50-390, 391/95-61, October 5, 1995.
NRC inspections:	Complete: Inspection Reports 50-390, 391/90-14 (August 3, 1990); 50-390, 391/90-23 (November 19, 1990); 50-390, 391/90-29 (January 29, 1991); 50390, 391/91-02 (March 6, 1991); 50-390, 391/91-03 (April 15, 1991); 50-390, 391/91-26 (December 6, 1991); 50-390, 391/93-74 (December 20, 1993); 50-390, 391/94-11 (March 16, 1994); 50-390, 391/94-24 (July 1, 1994); 50-390, 391/94-32 (May 16, 1994); 50-390, 391/94-55 (September 16, 1994); 50-390, 391/95-23 (May 2, 1995); 50-390, 391/95-27 (May 31, 1995); 50-390, 391/95-35 (June 28, 1995); 50-390, 391/95-53 (September 8, 1995); 50-390, 391/95-61 (October 5, 1995).

(12) Prestart Test Program (TAC M71924)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), October 17, 1989; NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to D. A. Nauman (TVA), March 27, 1991.
Implementation status:	Withdrawn by letter, J. H. Garrity (TVA) to NRC, February 13, 1992. Applicant will re-perform preoperational test program per Regulatory Guide 1.68, Revision 2.

(13) Quality Assurance Records (TAC M71923; TI 2512/028)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), December 8, 1989; NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to M. O. Medford (TVA) June 9, 1992 (Appendix X of SSER 9); letter, P. S. Tam (NRC) to M. O. Medford (TVA), January 12, 1993; letter, F. J. Hebdon (NRC) to M. O. Medford (TVA), August 12, 1993; letter, P. S. Tam (NRC) to O. D. Kingsley (TVA), April 25, 1994.
Implementation status:	100% (certified by letter, W. J. Museler (TVA), to NRC, April 27, 1994); staff concurrence in Inspection Report 50-390, 391/94-40, June 24, 1994.
NRC inspections:	Complete: Inspection Reports 50-390, 391/90-06 (April 25, 1990); 50-390, 391/90-08 (September 13, 1990); 50390, 391/91-08 (May 30, 1991); 50-390, 391/91-15 (September 5, 1991); 50-390, 391/91-29 (December 27, 1991); 50-390, 391/92-05 (April 17, 1992); 50-390, 391/92-10 (June 11, 1992); 50-390, 391/92-21 (September 18, 1992); 50-390, 391/93-11 (March 25, 1993); 50-390, 391/93-21 (April 9, 1993); 50-390, 391/93-29 (May 14, 1993); 50-390, 391/93-34 (July 5, 1993); 50-390, 391/93-35 (June 10, 1993); 50-390, 391/93-50 (September 3, 1993); 50-390, 391/93-59 (October 25, 1993); 50-390, 391/93-69 (November 12, 1993); 50-390, 391/93-70 (November 12, 1993); 50-390, 391/93-78 (December 16, 1993); 50-390, 391/93-86 (January 24, 1994); 50-390, 391/94-04 (February 23, 1994); 50-390, 391/94-09 (March 11, 1994); 50-390, 391/94-17 (April 1, 1994); 50-390, 391/94-28 (May 5, 1994); 50-390, 391/94-40 (June 24, 1994).

(14) Q-List (TAC M63590; TI 2512/029)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), September 11, 1989; NUREG-1232, Vol. 4; letters, P. S. Tam (NRC) to O. D. Kingsley (TVA), January 23, 1991 and March 17, 1994 (enclosure of this letter reproduced as Appendix AA in SSER 13).
Implementation status:	100% (certified by letter, W. J. Museler (TVA), to NRC, January 28, 1994); staff concurrence in Inspection Report 50-390, 391/94-27, April 21, 1994.
NRC inspections:	Complete: Inspection Reports 50-390, 391/90-08 (September 13, 1990); 50-390, 391/91-08 (May 30, 1991); 50-390, 391/91-29 (December 27, 1991); 50-390, 391/91-31 (January 13, 1992); 50-390, 391/93-20 (April 16, 1993); 50-390, 391/93-68 (November 12, 1993); 50-390, 391/94-27 (April 21, 1994).

(15) Replacement Items Program (TAC M71922; TI 2512/027)

Program review status:	Complete: Letter, S. C. Black (NRC) to O. D. Kingsley (TVA), November 22, 1989; NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to O. D. Kingsley (TVA), February 11, 1991 (Appendix N of SSER 6); letter, P. S. Tam (NRC) to M. O. Medford (TVA), July 27, 1992, April 5, 1994, and February 6, 1995.
Implementation status:	100% (certified by letter, R. R. Baron to NRC, October 13, 1995).
NRC inspections:	Complete: Inspection Reports 50-390, 391/91-08 (May 30, 1991); 50-390, 391/91-29 (December 27, 1991); 50- 390, 391/92-03 (March 16, 1992); 50-390, 391/92-11 (June 12, 1992); 50-390, 391/92-17 (July 22, 1992); 50-390, 391/92-21 (September 18, 1992); 50-390, 391/92-40 (January 15, 1993); 50-390, 391/93-22 (April 25, 1993); 50-390, 391/93-34 (July 9, 1993); 50-390, 391/93-38 (June 24, 1993); 50-390/94-201 (December 14, 1994); 50-390, 391/95-34 (June 23, 1995); 50-390, 391/95-50 (August 29, 1995).

(16) Seismic Analysis (TAC R00514; TI 2512/030)

Program review status:	Complete: Letters, S. C. Black (NRC) to O. D. Kingsley (TVA), September 7 and October 31, 1989; NUREG-1232, Vol. 4; SSER 6, Section 3.7.
Implementation status:	100% (certified by letter, J. H. Garrity (TVA) to NRC, December 2, 1991); staff concurrence in SSER 9, Section 3.7.1.
NRC inspections:	Complete: Inspection Reports 50-390, 391/89-21 (May 10, 1990); 50-390, 391/90-20 (September 25, 1990); audit report by L. B. Marsh, October 10, 1990.

(16)(a) Civil Calculation Program (TAC R00514)

Program review status:	No program review. A number of civil calculation categories are required by the Design Baseline and Verification Program CAP and constitute parts of the applicant's corrective actions. This program is regarded as complementary to but not part of the Seismic Analysis CAP. Staff efforts consist mainly of audits performed at the site and in the office.
Implementation status:	100% (final calculations transmitted by letter, W. J. Museler (TVA) to NRC, July 27, 1992).
NRC audits:	Complete: Memorandum (publicly available), T. M. Cheng (NRC) to P. S. Tam, January 23, 1992; letter, P. S. Tam (NRC) to D. A. Nauman (TVA), January 31, 1992; letters, P. S. Tam (NRC) to M. O. Medford

(TVA), May 26 and December 18, 1992 and July 2, 1993; 50-390, 391/93-07 (February 19, 1993); letter, P. S. Tam (NRC) to M. O. Medford (TVA), November 26, 1993.

(17) Vendor Information Program (TAC M71921; TI 2512/031)

Program review status:	Complete: Letter, P. S. Tam (NRC) to O. D. Kingsley (TVA), September 11, 1990 (Appendix I of SSER 5); Appendix I of SSER 11.
Implementation status:	100%.
NRC inspections:	Inspection Reports 50-390, 391/91-08 (May 30, 1991); 50-390, 391/91-29 (December 27, 1991); 50-390, 391/93-27 (May 14, 1993); 50-390, 391/95-10 (March 17, 1995); to come.

(18) Welding (TAC M72106; TI 2512/032)

Program review status:	Complete: Inspection Reports 50-390, 391/89-04 (August 9, 1989); 50-390, 391/90-04 (May 17, 1990); NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to D. A. Nauman (TVA), March 5, 1991; these inspection reports also address recurrence control: 50-390, 391/93-02 (February 2, 1993); 50-390, 391/93-84 (December 21, 1993); 50-390, 391/94-79 (January 11, 1995).
Implementation status:	100% (certified by letter, W. J. Museler (TVA) to NRC, January 9, 1993); staff concurrence in Inspection Report 50-390, 391/94-79, January 11, 1995.
NRC inspections:	Complete: Inspection Reports 50-390, 391/89-04 (August 9, 1989); 50-390, 391/90-04 (May 17, 1990); 50-390, 391/90-20 (September 25, 1990); 50-390, 391/91-05 (May 28, 1991); 50-390, 391/91-18 (October 8, 1991); 50-390, 391/91-23 (November 21, 1991); 50390, 391/91-32 (February 10, 1992); 50-390, 391/9220 (August 12, 1992); 50-390, 391/92-28 (October 9, 1992); 50-390, 391/93-02 (February 2, 1993); 50-390, 391/93-19 (March 15, 1993); 50-390, 391/93-38 (June 24, 1993); 50-390, 391/93-84 (December 21, 1993); 50-390, 391/94-05 (February 19, 1994); 50-390, 391/94-16 (March 15, 1994); 50-390, 391/94-49 (July 21, 1994); 50-390, 391/94-79 (January 11, 1995).

1.13.2 Special Programs

(1) Concrete Quality (TAC M63596; TI 2512/033)

Program review status:	Complete: NUREG-1232, Vol. 4.
Implementation status:	100% (certified by letter, E. Wallace (TVA) to NRC,

	August 31, 1990); staff concurrence in SSER 7, Section 3.8.2.1.
NRC inspections:	Complete: NUREG-1232, Vol. 4; Inspection Reports 50-390, 391/89-200 (December 12, 1989); 50-390, 391/90-26 (January 8, 1991).

(2) <u>Containment Cooling (TAC M77284; TI 2512/034)</u>

Program Review status:	Complete: NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to D. A. Nauman (TVA), May 21, 1991 (Section 6.2.2 of SSER 7).
Implementation status:	100% (certified by letters, W. J. Museler (TVA) to NRC, December 30, 1993, and R. R. Baron (TVA) to NRC, September 28, 1995); staff concurrence in Inspection Report 50-390, 391/95-38, July 11, 1995.
NRC inspections:	Complete: Inspection Report 50-390, 391/93-56 (September 20, 1993); 50-390, 391/95-38 (July 11, 1995).

(3) <u>Detailed Control Room Design Review (TAC M63655; TI 2512/035)</u>

Program review status:	Complete: Appendix D of SER; NUREG-1232, Vol. 4; Section 18.1, and Appendix L of SSER 6; Section 18.1 of SSER 5 and 15.
Implementation status:	100%.
NRC inspections:	Complete: Inspection Reports 50-390, 391/94-22 (April 28, 1994); audit reports in SSER 5 and 15.

(4) <u>Environmental Qualification Program (TAC M63591; TI 2512/036)</u>

Program review status:	Complete: NUREG-1232, Vol. 4; Section 3.11 of SSER 15.
Implementation status:	100%.
NRC inspections:	Complete: Inspection Reports 50-390, 391/93-63 (October 18, 1993; 50-390, 391/94-28 (April 18, 1994); 50-390, 391/94-74 (January 13, 1995); 50-390, 391/95-15 (April 5, 1995); 50-390, 391/95-54 (September 8, 1995).

(5) <u>Master Fuse List (TAC M76973; TI 2512/037)</u>

Program review status:	Complete: NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to O. D. Kingsley (TVA), February 6, 1991; letter, P. S. Tam (NRC) to TVA Senior Vice President, March 30, 1992 (Appendix U of SSER 9).
Implementation status:	100% (certified by letter, W. Museler (TVA) to NRC, April 2, 1993); staff concurrence in Inspection

Report 50-390, 391/93-31, May 6, 1993.

NRC inspections:	Complete: Inspection Reports 50-390, 391/86-24 (February 12, 1987); 50-390, 391/92-05 (April 17, 1992); 50-390, 391/92-09 (June 29, 1992); 50-390, 391/92-27 (September 25, 1992); 50-390, 391/93-31 (May 6, 1993).

(6) Mechanical Equipment Qualification (TAC M76974; TI 2512/038)

Program review status:	Complete: NUREG-1232, Vol. 4; Section 3.11 of SSER 15.
Implementation status:	100%.
NRC inspections:	Complete: Inspection Reports 50-390, 391/95-15 (April 5, 1995); 50-390, 391/95-54 (September 8, 1995).

(7) Microbiologically Induced Corrosion (TAC M63650; TI 2512/039)

Program review status:	Complete: NUREG-1232, Vol. 4; Appendix Q of SSER 8; Appendix Q of SSER 10.
Implementation status:	100% (certified by letter, W. J. Museler (TVA) to NRC, August 31, 1993); staff concurrence in Inspection Report 50-390, 391/93-67, November 1, 1993.
NRC inspections:	Complete: Inspection Reports 50-390, 391/90-09 (June 22, 1990); 50-390, 391/90-13 (August 2, 1990); 50-390, 391/93-01 (February 25, 1993); 50-390, 391/93-09 (March 26, 1993); 50-390, 391/93-67 (November 1, 1993).

(8) Moderate Energy Line Break Flooding (TAC M63595; TI 2512/040)

Program review status:	Complete: NUREG-1232, Vol. 4; Section 3.6 of SSER 11.
Implementation status:	100%; staff concurrence in Inspection Report 50-390, 391/95-61, October 5, 1995.
NRC inspections:	Complete: Inspection Reports 50-390, 391/93-85 (January 14, 1994); 50-390, 391/95-53 (September 8, 1995); 50-390, 391/95-61 (October 5, 1995).

(9) Radiation Monitoring Program (TAC M76975; TI 2512/041)

Program review status:	Complete: NUREG-1232, Vol. 4; this program covers areas addressed in Chapter 12 of the SER and SSERs.
Implementation status:	Full implementation expected by October 1995.
NRC inspections:	Inspection Reports 50-390, 391/94-56 (October 6,

1994); to come.

(10) Soil Liquefaction (TAC M77548; TI 2512/042)

Program review status: Complete: NUREG-1232, Vol. 4; letter, P. S. Tam (NRC) to TVA Senior Vice President, March 19, 1992; Section 2.5 of SSER 9.

Implementation status: 100% (certified by letter, W. J. Museler (TVA) to NRC, July 27, 1992); staff concurrence in SSER 11, Section 2.5.4.4.

NRC inspections: Complete: Inspection Reports 50-390, 391/89-21 (May 10, 1990); 50-390, 391/89-03 (May 11, 1989); audit report by L. B. Marsh (NRC) (October 10, 1990); audit report, P. S. Tam (NRC) to D. A. Nauman (TVA), January 31, 1992; audit report, P. S. Tam (NRC) to M. O. Medford (TVA), May 26 and December 18, 1992; 50-390, 391/92-45 (February 17, 1993).

(11) Use-as-Is CAQs (TAC M77549; TI 2512/043)

Program review status: Complete: NUREG-1232, Vol. 4.

Implementation status: 100% (certified by letter, W. J. Museler (TVA) to NRC, July 24, 1992); staff concurrence in Inspection Report 50-390, 391/93-10, March 19, 1993.

NRC inspections: Complete: Inspection Reports 50-390, 391/90-19 (October 15, 1990); 50-390, 391/91-08 (May 30, 1991); 50-390, 391/93-10 (March 19, 1993).

3 DESIGN CRITERIA--STRUCTURES, COMPONENTS, EQUIPMENT, AND SYSTEMS

3.9 Mechanical Systems and Components

3.9.6 Inservice Testing of Pumps and Valves (Unit 1)

3.9.6.1 Pump Test Program

As required by 10 CFR 50.55a, inservice testing (IST) of certain ASME Code Class 1, 2, and 3 pumps and valves should be performed in accordance with Section XI of the ASME Code and applicable addenda, except where alternatives have been authorized or relief has been requested by the applicant and granted by the Commission pursuant to Sections (a)(3)(i), (a)(3)(ii), or (f)(6)(i) of 10 CFR 50.55a. In proposing alternatives or requesting relief, the applicant must demonstrate that (1) the proposed alternatives provide an acceptable level of quality and safety, (2) compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety, or (3) conformance is impractical for its facility.

In SSER 14, the staff reviewed the applicant's pump test program for Unit 1 and authorized testing alternatives. Subsequent to publication of SSER 14, the applicant submitted a letter dated June 29, 1995, requesting approval of an alternative for set pressure testing of the three pressurizer safety relief valves that provide overpressure protection for the reactor coolant system. By letter of August 9, 1995, the applicant provided additional information to substantiate the request.

The staff reviewed the applicant's request and by letter of September 5, 1995, approved the proposed alternative for Unit 1 per 10 CFR 50.55(a)(3)(ii). That letter is incorporated by reference. The staff tracked its efforts by TAC M92773.

6 ENGINEERED SAFETY FEATURES

6.2 Containment Systems

6.2.3 Secondary Containment Functional Design

In the SER, the staff stated that the auxiliary building gas treatment system (ABGTS) is started automatically upon receipt of one of the following signals:

(1) Phase A containment isolation signal from either reactor unit
(2) high-radiation signal from the fuel-handling area radiation monitors
(3) high-radiation signal from the auxiliary building exhaust vent monitors
(4) high temperature in the auxiliary building intakes for the general supply fan

By Amendment 89 to the FSAR, Section 6.2.3.2.3, "Auxiliary Building Gas Treatment System (ABGTS)," the applicant deleted the high-radiation signal from the auxiliary building exhaust vent monitors (signal 3 above) from the list of ABGTS initiation signals. The staff finds the deletion acceptable for the following reasons:

(1) The deletion does not compromise the capability of the system to perform one of its safety functions, namely, filtering radioactive releases to the environment that result from a postulated fuel-handling accident in the fuel-handling area of the auxiliary building. This is because the system will continue to be initiated automatically on a high-radiation signal from the fuel-handling area radiation monitors (signal 2 above). Operability of radiation monitors in the fuel pool area is ensured by Table 3.3.8.1, "ABGTS Actuation Instrumentation," of the Unit 1 Technical Specifications (TSs).

(2) During a postulated design-basis loss-of-coolant accident (LOCA), a small fraction of containment radioactivity leaks into areas of the auxiliary building. This radioactivity gets diluted in the area atmosphere, and travels via ducts and rooms to the fuel-handling area or waste packaging area of the auxiliary building. These areas are serviced by the ABGTS, which filters the leakage before discharge to the environment. Also, airborne radioactivity arising from any emergency core cooling system (ECCS) component leakage, during the recirculation phase of ECCS operation, is filtered by the ABGTS before discharge to the environment. Following a postulated design-basis LOCA, automatic safety injection occurs which initiates Phase A containment isolation. The Phase A containment isolation, in turn, initiates the ABGTS (see signal 1 above). TS Table 3.3.8.1 also includes the Phase A containment isolation signal in the list of ABGTS actuation signals. From the discussion above, it is obvious that following a LOCA, the ABGTS will be initiated and will perform its other safety functions, namely, filtering the leakage into the auxiliary building from the containment and filtering the airborne activity arising from ECCS component leakage. The deletion of the signal does not compromise the capability of the system to perform its other safety functions.

The staff tracked this effort by TAC M92973.

6.4 Control Room Habitability

In the SER, the staff stated that placing the control room ventilation system (CRVS) in the pressurization mode would supply 200 cubic feet per minute (cfm) of pressurized air to the control room envelope through adsorbers, while 4000 cfm would be recirculated through redundant particulate and carbon filtration components. These numbers were preliminary and subject to change because the pressurization flow rate necessary to maintain the control room envelope at a positive pressure is determined by the actual leakage characteristics of that envelope. In Amendment 90 to the FSAR, the applicant provided updated flow rate data (based on actual control room envelope leakage data) and updated dose analyses.

On the basis of these latest analyses, the applicant showed that if the pressurization flow rate (supplied from outside air) is in excess of 711 cfm, the allowable dose to control room operators could be exceeded under certain postulated design-basis accident conditions. Thus, the maximum pressurization flow rate is 711 cfm. The minimum pressurization flow rate is dependent on (and must be higher than) the amount of control room envelope leakage. The latest data, as identified in FSAR Amendment 90, shows this exfiltration rate to be about 270 cfm in the emergency mode of operation. The flow rates cited in the SER were actually the design flow rates for a pressurization fan and an air filtration unit. The design flow rate for each of the two pressurization fans is now 711 cfm, and the design flow rate for each of the two air filtration units is still 4000 cfm. Since the 711 cfm outside pressurization flow rate is supplied to the inlet of the filtration units, the actual recirculation air flow rate per train is the difference between 711 cfm and 4000 cfm, or 3289 cfm.

These changes are considered clarifications based on the actual control room and equipment designs, and do not affect the conclusions reached in the SER or its supplements (SSERs 5, 11, and 16). Therefore, the control room habitability systems are still acceptable.

The staff tracked its efforts by TAC M92973.

9 AUXILIARY SYSTEMS

9.2 Water Systems

9.2.1 Essential Raw Cooling Water and Raw Cooling Water Systems

The staff reviewed the essential raw cooling water (ERCW) system in the SER and SSERs 9 and 10. By Amendment 90 to the FSAR, Table 9.2-1, the applicant stated that the ERCW system pumps did not perform in accordance with their original design-basis. During preoperational testing, the ERCW pumps did not match the original performance curves supplied by the pump vendor. However, the original design-basis capacity and head for each of the ERCW pumps was based on two-unit operation. Because the ERCW system is a continuously shared system, even during accidents, the design is such that the pumps are designed to supply cooling water to two separate trains, one for each unit. To support single-unit operation, the applicant reanalyzed the ERCW system flow requirements to determine the minimum ERCW pump performance requirements for Unit 1 operation only. The applicant's analysis showed that if the ERCW pumps could perform at no less than 72 percent of the original vendor-supplied pump performance curves, the design-basis flow requirements for Unit 1 operation would be met. On the basis of the preoperational ERCW pump tests (which showed the pumps were capable of performing at more than 72 percent of the performance curves), the applicant concluded that the performance of the ERCW pumps is acceptable for Unit 1 operation only.

In Section 9.2.1 of the SER, the staff concluded that the ERCW system conformed to a number of general design criteria (GDCs), including GDC 5, "Sharing of Systems, Structures and Components," with respect to sharing of essential systems. As a result of the applicant's determination that the ERCW pumps do not conform to their original design-basis capability, the staff concludes that the ERCW system does not conform to GDC 5 for two-unit operation. However, on the basis of the applicant's analysis, the staff concludes that the ERCW system does conform to GDC 5 (not shared) for single-unit operation. The staff, therefore, concludes that the ERCW system is acceptable for Unit 1 operation.

The staff tracked its efforts by TAC M92973.

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.

12 RADIATION PROTECTION

12.4 Radiation Protection Design Features

In SSER 14, the staff completed its review of this section. Subsequently, by FSAR Amendments 89 and 90, the applicant revised the discussions of the installed area radiation monitoring and the fixed airborne radiation monitoring systems. In addition, Amendment 90 revised the estimated maximum radiation dose rates depicted on the radiation zone maps (FSAR Figures 12.3-1 through 12.3-19) for several areas in the plant.

The discussion of area monitor calibration and maintenance in FSAR Section 12.3.4 was revised to clarify the distinctions between a monitor calibration, a monitor channel operational test, and a checksource functional test. The frequency of calibration for area radiation monitors was also revised from at least once a quarter to at least once per refueling cycle with a channel operational test at least once per quarter.

The text in FSAR Section 12.3 and Table 12.3-5 was revised to delete the discussion of fixed airborne radiation monitors in the Unit 2 hot sample room and the Unit 1 control room, and to replace them with portable continuous air monitors (CAMs). These portable CAMs have a range of from 0.1 to 1.0 times the derived airborne concentration limits in 10 CFR Part 20 Appendix B, and provide a local high-level alarm. The staff finds acceptable the use of these portable CAMs for meeting the monitoring requirements of 10 CFR Part 20. The operability of the radiation monitor in the Unit 1 control room ventilation system was not affected by Amendments 89 and 90.

The staff finds that these changes are acceptable and do not change the staff's conclusion documented in SSER 14. The staff tracked this effort by TAC M93601.

14 INITIAL TEST PROGRAM

In SSERs 12, 14, and 16, the staff found the applicant's Initial Test Program (ITP) up to FSAR Amendment 89 acceptable. Subsequently, by letter of July 13, 1995, and FSAR Amendment 90, the applicant made changes.

The staff tracked its efforts by TAC M92973.

14.2 Preoperational Tests

The following evaluation reflects the numbering system in SSER 14.

Item 1

(e) As stated in SSER 14, in an August 19, 1994, letter, TVA had proposed to demonstrate operability and to confirm the adequacy of design and performance criteria for fuel handling and vessel servicing equipment not associated with manipulation of spent fuel, by performing a combination of acceptance test instructions, special performance tests, and work orders.

In FSAR Amendment 84, Section 14.2.7, Subparagraph 4.A.(1)(h), the applicant takes exception to testing static loads at 125 percent of rated load on three of the four Unit 1 fuel-handling devices (spent fuel pit bridge crane, refueling machine, and 125-ton auxiliary building crane main hook, including both polar crane hooks) in accordance with the guidance in Regulatory Guide (RG) 1.58 (Appendix A, Subparagraph 1.m.4). The applicant's justification for this exception is that, except for the auxiliary hook of the 125-ton auxiliary building crane, (1) all the fuel-handling equipment has been previously tested at 125-percent rated capacity and (2) this equipment had not undergone extensive repairs or modifications that would warrant such testing. However, the applicant committed to performing the requisite 125-percent-rated capacity test of the 125-ton auxiliary building crane auxiliary hook.

Subsequently, in FSAR Amendment 88, Section 14.2.7, Subparagraph 4.A.(1)(h), the applicant proposed that cranes not associated with spent fuel movement be operationally tested by a combination of acceptance test instructions (ATIs), component tests (CTs), and special performance tests (SPTs) as described in the enclosures to the applicant's July 14 and August 14, 1994, letters. The balance of equipment used for handling of spent fuel would be tested under FSAR Table 14.2-1, Sheets 74 and 75, "Fuel Handling Equipment Test Summary," as included in Amendment 88 to FSAR Chapter 14. In SSER 14 the staff found that the proposed testing program elements, controls, and commitments described by TVA provided an acceptable approach to demonstrate satisfactory operability of the affected systems, or portions thereof, and to confirm the adequacy of their design and performance criteria. This issue was thus closed in SSER 14.

However, in a July 13, 1995, letter, and subsequently in FSAR Amendment 90, the applicant proposed to rescind its commitment to conduct further testing of fuel-handling and vessel servicing equipment not associated with manipulation of spent fuel as had been approved by the staff in SSER 14. In that letter, the applicant presented a detailed synopsis of former and recent operability and performance testing, periodic inspections, and post-modification testing that provides the bases for the conclusion that the test methods and acceptance criteria specified in the Fuel-Handling and Vessel Servicing Equipment Test Summary have been met.

On the basis of the acceptable results achieved during the performance testing, periodic inspections, and post-modification testing as outlined by TVA in the July 13, 1995, letter, the staff agrees that TVA has presented suitable evidence that the adequacy of design and performance criteria for the subject equipment has been verified and, therefore, satisfy the provisions of RG 1.68, Appendix A, Subparagraph 1.m.4. This issue is closed.

14.2.3 Conclusion

The staff finds the ITP, as delineated in Chapter 14 of the FSAR, updated by Amendment 90, generally comprehensive and encompasses the major phases of the testing program guidance presented in the Standard Review Plan (NUREG-0800) and Standard Format (Regulatory Guide 1.70).

15 ACCIDENT ANALYSIS

15.2 Normal Operation and Anticipated Transients

15.2.3 Change in Coolant Inventory Transients

In the SER, the staff reviewed two events which could change the primary system inventory: (1) opening of pressurizer safety/relief valve and (2) actuation of the emergency core cooling system (ECCS). By Amendment 90, the applicant revised FSAR Section 15.2.14 to update the transient analysis for the postulated event of inadvertent ECCS operation. The updated analysis was performed after the boron injection tank (BIT) and associated 900 gallons of 20,000 ppm boron were deleted from the Watts Bar design basis (see Section 15.3.2 of SSER 3). The applicant submitted more information in a letter dated October 12, 1995, to support its original submittal.

The ECCS at power could be spuriously initiated by equipment malfunction, operator error, or a false actuation signal. This postulated event is considered an incident with moderate frequency. The acceptance criteria established for this class of events are

(1) Transient peak pressures in both primary and secondary systems are within 110 percent of the design values.

(2) Fuel cladding integrity is maintained by ensuring that the minimum departure-from-nucleate-boiling ratio (DNBR) remains above the 95/95 DNBR limit established for the plant.

(3) The incident does not generate a more serious plant condition without other faults occurring independently.

To demonstrate that these three acceptance criteria are met following an inadvertent operation of ECCS at Watts Bar, the applicant analyzed this postulated event with conservative assumptions. Cases were studied assuming a reactor trip followed by a turbine trip at the same time of the spurious safety injection, and a delayed reactor trip followed by a turbine trip initiated by the low pressurizer pressure or manual trip.

The most limiting case with respect to departure from nucleate boiling (DNB) is the case of delayed reactor trip and turbine trip following an inadvertent safety injection. In this scenario, the reactor experiences a negative reactivity excursion due to the injected boron causing a decrease in reactor power. The mismatch between the reactor and turbine power causes a drop in primary temperature, reactor pressure, and pressurizer water level. The reactor trip will be initiated by low pressurizer pressure or by manual trip. This scenario is most limiting with respect to DNB because of therapid primary system depressurization at the initial phase of the transient. However, because reactor power and primary temperature are reduced at the beginning of the transient, the analysis indicates that the DNBR remains above its initial value throughout the transient.

The applicant considered that the case of the reactor and turbine trip occurring simultaneously with spurious safety injection starts is the limiting case with respect to system integrity, and stated that a more serious plant condition does not occur. The analysis for this scenario indicates that the pressurizer pressure increases until the pressurizer power-operated valves (PORVs) are actuated and the pressurizer water level increases throughout the transient. However, at no time does the pressurizer become water-solid. Therefore, the potential of the water relief through the pressurizer safety/relief valves (PSRVs) is prevented.

In response to the staff's concern regarding the use of PORVs and pressurizer spray in the applicant's analysis - since the PORVs may be isolated during power operation - and that the pressurizer spray is not a safety-related system, the applicant sent additional clarification in its letter of October 12, 1995. The applicant stated that a sensitivity study indicates that without taking credit of the PORVs and the pressurizer spray, the transient primary system pressure will reach the PSRV's lifting setpoint. However, the relief capacity of any of the three PSRVs is sufficient to prevent further pressure increase until operator action terminates ECCS operation using emergency operating procedures (EOPs). By analysis, the applicant confirms that the acceptance criteria regarding peak system pressure are met.

On the basis of this evaluation, the staff finds that the applicant's revised analyses for the postulated event of inadvertent ECCS operation are acceptable.

The staff tracked this effort by TAC M92973.

15.4 Radiological Consequences of Accidents

In the SER and SSER 15, the staff evaluated radiological consequences of postulated design-basis accidents. Subsequent to issuance of SSER 15, the applicant submitted revised information. On the basis of the revised information, the staff's evaluation follows. The staff tracked this effort by TAC M92973.

15.4.1 Loss-of-Coolant Accident

Containment Leakage Contribution

In Amendment 90, the applicant increased the amount of leakage which enters the auxiliary building following the loss-of-coolant accident (LOCA) from 10 percent to 25 percent of the primary containment leakage, assuming that this leakage was exhausted directly to the atmosphere during the first 4 minutes of the accident. After the first 4 minutes, the leakage is exhausted through the auxiliary building gas treatment system (ABGTS) with a holdup time of 0.3 hour in the auxiliary building before being exhausted.

The staff assumes that all leakage into the auxiliary building for the first 10 minutes of the accident is immediately released to the environment. For all times after the first 10 minutes into the accident, the staff assumes that the leakage is exhausted through the ABGTS.

Seventy-five percent of the leakage from the primary containment enters the shield building annulus where the staff assumes that it goes directly to the intake of the shield building annulus recirculation/exhaust system. Following passage through the emergency gas treatment system filters, a fraction of this leakage is assumed to be exhausted to the atmosphere with the remainder recirculated to the shield building annulus where credit is given for mixing in 50 percent of the annulus free volume. The split between the exhaust and recirculation fractions was assumed to be proportional to the air flow rates in the exhaust and recirculation paths of the systems.

The applicant revised the annulus ventilation flow distribution (see revised Table 15.2); the decrease in flow rates from 4,000 to 3,600 cubic feet per minute enhances the removal process.

On the basis of these changes made by the applicant, the staff recalculated the postulated design-basis loss-of-coolant accident. The staff's revised assumptions for the dose calculations are shown in Table 15.2. The LOCA doses calculated by the staff are shown in Tables 15.1; they are within the guidelines of 10 CFR Part 100.

Post-LOCA Leakage From ESF System Outside Containment

The applicant's analysis assumptions and calculations were revised in Amendment 90. The emergency core cooling system recirculation mode starts at 10 minutes instead of 30 minutes after the loss-of-coolant accident. The iodine partition factor of 0.1 instead of 0.01 is assumed for the total leakage. If a source of leakage should develop, such as a pump seal failure, a fraction of the iodine could become airborne and exit to the atmosphere. Since the emergency core cooling system area in the auxiliary building is served by an safety-grade air filtration system (ABGTS), the staff concludes that the doses resulting from the postulated leakage of recirculation water would be low, and result in total doses that are within the guidelines of 10 CFR Part 100.

The staff evaluated the possible increase in the doses to the control room operators in the postulated design-basis LOCA from the ECCS loop leakage. The staff concluded that ECCS loop leakage produced essentially no change in doses from what the staff reported in Section 6.4 of SSER 16. Therefore, the conclusion about the acceptability of the control room doses in SSER 16 is still valid.

Table 15.1 (Revised) Radiological consequences of design-basis accidents

Postulated accident	Exclusion area boundary, rems (sievert)		Low population zone, rems (sievert)	
	Thyroid	Whole body	Thyroid	Whole body
Loss-of-coolant accident				
Containment leakage				
0-2 hr	25.9 (0.26)	0.011 (.0001)	4.7 (0.05)	0.02 (0.0002)
2-8 hr	-	-	0.2 (0.002)	0.03 (0.0003)
8-24 hr	-	-	0.11 (0.001)	<0.1 (<0.001)
24-96 hr	-	-	0.11 (0.001)	<0.1 (<.0001)
96-720 hr			3.1 (0.03)	<0.01 (<0.001)
Total containment leakage	25.9 (0.26)	0.01 (0.001)	5.2 (0.05)	0.02 (0.0002)
ECCS component leakage	0.3 (0.003)	0.01 (0.001)	1.4 (0.01)	0.01 (0.0001)
TOTAL LOCA	26.0 (0.26)	0.02 (0.0002)	6.6 (0.07)	0.03 (0.0003)
Main steamline break outside secondary containment				
Long-term operation case (Case 2)	11.0 (0.11)	<0.1	11.2 (0.1)	<0.1
Short-term operation case (Case 3)	13.6 (0.14)	<0.1	13.7 (0.14)	<0.1
Control rod ejection accident				
In containment leakage pathway	53.5 (0.54)	<0.9	84.0 (0.8)	0.4 (0.004)
In secondary system release pathway	18.3 (0.18)	<1.0	6.0 (0.06)	<0.1
Fuel-handling accident				
In fuel-handling area	1.5 (0.02)	<1.0	0.2 (0.002)	<0.1
Inside primary containment	39 (0.39)	0.6 (0.01)	2.8 (0.028)	<0.1
Small-line failures outside containment	26.0 (0.26)	<0.1	4.6 (0.046)	<0.1
Steam generator tube rupture				
(1) DEI-131 at 60 µCi/gram	111.5 (1.12)	<0.1	24.0 (0.24)	<0.1
(2) DEI-131 at 1 µCi/gram	19.9 (0.2)	<0.1	6.0 (0.06)	<0.1

Note: DEI-131 = dose equivalent iodine-131.

Table 15.2 Assumptions used for calculating the radiological consequences following a postulated loss-of-coolant accident

Item		Assumption
Power level (MWt)		3592
Operating time (yr)		3
Fractions of core inventory available for leakage (%)		
Iodines		25
Noble gases		100
Initial iodine composition in containment (%)		
Elemental		91
Organic		4
Particulate		5
Primary containment volumes (ft^3)		
Upper compartment		6.51E5
Lower compartment (including ice condenser)		5.85E5
Shield building annulus volume (ft^3)		3.75E5
Mixing fraction in annulus (%)		50
Annulus ventilation flow distribution (ft^3)		
Time step	Recirculation flow (ft^3/min)	Exhaust flow (ft^3/min)
0-30 sec	0	0
30-105 sec	245	3355
105-270 sec	831	2769
370-603 sec	1939	1661
603-2100 sec	3076	524
2100 sec-30 days	3350	250
Filter efficiencies (%)		
Elemental iodine		99
Organic iodine		95
Particulate iodine		99
Ice condenser removal efficiency (%)		
Elemental iodine		30
Flowrate through ice condenser (ft^3)		40,000
Period of ice condenser effectiveness (min)		10-60
Primary containment leak rates (%)		
0-24 hr		0.25
24 hr-30 days		0.125
Bypass leakage fraction (%)		0
Minimum exclusion area boundary distance (m)		1250
Low population zone distance (m)		4828
Atmospheric diffusion (X/Q) values (sec/m^3)		
0-2 hr at 1250 m		5.5E-4
0-8 hr at 4828 m		1.0E-4
8-24 hr at 4828 m		6.0E-5
1-4 days at 4828 m		2.6E-5
4-30 days at 4828 m		8.0E-6

18 HUMAN FACTORS ENGINEERING

18.1 Detailed Control Room Design Review

In SSER 15, the staff concluded that the detailed control room design review (DCRDR) program implemented at Unit 1 conforms to the DCRDR requirements of Supplement 1 to NUREG-0737. In that evaluation, the staff stated that corrective actions for six safety-significant human engineering deficiencies (HEDs) were not then implemented but would be fully implemented before fuel loading. For these six HEDs, the staff stated that "the applicant's proposed corrective actions, commitments, and schedules pertaining to HED numbers 15, 19, 93, 119, 151, and 157 are satisfactory."

By letter dated September 26, 1995, the applicant notified the staff of its reassessment of the safety significance of HED 151, downgrading it from Category 1 (safety significant) to Category 4 (not safety significant). HED 151 identified Eberline condenser vacuum pump exhaust radiation monitoring system problems (e.g., problems related to reliability, accuracy, information input and processing capabilities, and documentation/procedure adequacy) that detract from the usability of the system. The applicant's justification for reassessing this HED was that since the original DCRDR evaluation, various design changes have significantly reduce the importance of this particular system. Specifically, (1) shield building vent parameters have been removed from the Eberline system and placed on separate hardware in the control room, (2) condenser vacuum pump exhaust radiation level is available on the emergency response facility data system (ERFDS) which has a superior operator interface to the Eberline system interface, and (3) all the parameters needed to calculate the radiation release rate are available on the ERFDS.

The staff reviewed the applicant's revised information in the September 26, 1995 letter, and concludes that the justification for downgrading HED 151 from safety significant to not safety significant is satisfactory for resolving this HED.

The staff tracked its efforts by TAC M63655.

APPENDIX A

CHRONOLOGY OF RADIOLOGICAL REVIEW OF WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2, OPERATING LICENSE REVIEW

The following is a list of documents; most of them are referenced in this SSER. In no way is this an exhaustive list of all correspondence exchanged between the staff and the applicant during this period. The reader may obtain an exhaustive list through the NRC document control system (NUDOCS), the Public Document Room, or the Local Public Document Room.

NRC Letters and Summaries

July 24, 1995	Summary by M. T. Bugg of July 19, 1995, meeting regarding open issues in the final draft of the Technical Specifications.
August 1, 1995	Summary by M. T. Bugg of meeting of July 3, 1994 to discuss Unit 1's pressure-temperature limit methodology.
August 2, 1995	Letter, P. S. Tam to N. J. Liparulo (Westinghouse), approving request to withhold topical report on reactor coolant flow measurement uncertainty from public disclosure.
August 3, 1995	Notice by P.S. Tam of August 24, 1995, licensing status meeting.
August 9, 1995	Letter, P. S. Tam to O. D. Kingsley (TVA), transmitting trip report regarding inspection of condition of structures and civil engineering features.
August 10, 1995	Notice by P. S. Tam of meeting of August 14-15, 1995, to discuss open issues in the final draft Technical Specifications.
August 11, 1995	Letter, P. S. Tam to O. D. Kingsley (TVA), requesting additional information regarding relocation of certain administrative requirements from the draft Technical Specifications.
August 14, 1995	Letter, F. J. Hebdon to O. D. Kingsley (TVA), finding Revision 6 of the TVA organizational topical report acceptable.
August 17, 1995	Summary by R. J. Giardina of meeting of August 14-15, 1995, regarding open issues in the final draft of the Technical Specifications.

August 18, 1995	Notice by P. S. Tam of August 25, 1995, meeting regarding operation readiness review team inspection findings.
August 18, 1995	Notice by P. S. Tam of September 5, 1995, meeting with the public to take place at Quality Inn, Sweetwater, Tennessee.
August 23, 1995	Notice by P.S. Tam of September 7, 1995, management meeting.
August 29, 1995	Summary by P. S. Tam of meeting of August 23, 1995, regarding administrative requirements relocated from the final draft Technical Specifications.
August 29, 1995	Summary by P. S. Tam of meeting of August 24, 1995, regarding various licensing issues.
September 5, 1995	Letter, F. J. Hebdon to O. D. Kingsley (TVA), granting relief from certain testing requirements of Section XI of the ASME Code.
September 14, 1995	Summary by P. S. Tam of management meeting of September 7, 1995, regarding status of various issues.
September 18, 1995	Letter, F. J. Hebdon to O. D. Kingsley (TVA), granting additional relief to the preservice inspection program.
September 22, 1995	Letter, F. J. Hebdon to O. D. Kingsley (TVA), approving pressure-temperature limit methodology.
September 25, 1995	Letter, F. J. Hebdon to O. D. Kingsley (TVA), transmitting information to assist efforts to protect against design-basis sabotage.
September 29, 1995	Letter, P. S. Tam to O. D. Kingsley (TVA), transmitting copies of Supplement 16 of the Watts Bar Safety Evaluation Report (NUREG-0847).
October 2, 1995	Letter, P. S. Tam to O. D. Kingsley (TVA), advising that handout material received in February 23, 1995, meeting will be withheld from public disclosure.
October 2, 1995	Letter, P. S. Tam to O. D. Kingsley, transmitting copy of environmental assessment related to TVA's proposed exemption to certain provisions of 10 CFR Part 50, Appendix E.

TVA Letters

August 2, 1995	Letter, R. R. Baron to NRC, certifying the final draft Technical Specifications of June 13, 1995.

August 9, 1995	Letter, R. R. Baron to NRC, requesting relief from certain ASME Section XI preservice inspection requirements.
August 9, 1995	Letter, O. J. Zeringue to NRC, providing additional information to support request for relief from certain requirements regarding pressurizer relief valve testing.
August 9, 1995	Letter, R. R. Baron to NRC, providing revised response to Generic Letter 89-10 regarding motor-operated valves.
August 16, 1995	Letter, R. R. Baron to NRC, transmitting draft pages to be included in FSAR Amendment 90.
August 17, 1995	Letter, M. O. Medford to NRC, responding to Generic Letter 92-01, Revision 1, Supplement 1, regarding reactor vessel structural integrity.
August 21, 1995	Letter, R. R. Baron to NRC, providing information regarding use of jumpers for testing in Eagle-21 cabinets.
August 21, 1995	Letter, R. R. Baron to NRC, commenting on the draft environmental protection plan, which will become Appendix B to the operating license.
August 21, 1995	Letter, R. R. Baron to NRC, providing updated information regarding Thermo-Lag 770-1 fire endurance test.
August 24, 1995	Letter, R. R. Baron to NRC, commenting on draft low-power operating license for (NPF-20) for Unit 1.
August 28, 1995	Letter, R. R. Baron to NRC, informing of recent changes to ECCS evaluation model and providing schedule to perform the next small-break LOCA analysis.
August 31, 1995	Letter, P. P. Carier to NRC, submitting Revision 6 of the TVA quality assurance program.
September 1, 1995	Letter, R. R. Baron to NRC, providing additional information regarding administrative requirements relocated from the final draft Technical Specifications to the quality assurance program.
September 6, 1995	Letter, P. P. Carier, providing additional information to support requested exemption from certain provisions of 10 CFR Part 50, Appendix E.
September 8, 1995	Letter, R. R. Baron to NRC, providing additional information regarding methodology used to develop cold overpressure mitigation system setpoints.

September 14, 1995	Letter, R. R. Baron to NRC, providing additional ampacity test results of cables wrapped in Thermo-Lag materials.
September 26, 1995	Letter, R. R. Baron, requesting relief from certain testing requirements of ASME Section XI for some relief valves.
September 26, 1995	Letter, R. R. Baron to NRC, revising some information previously submitted for detailed control room design review.
September 27, 1995	Letter, R. R. Baron to NRC, notifying of complete implementation of the design baseline verification program.

APPENDIX E

PRINCIPAL CONTRIBUTORS

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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-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 to adequately ensure that water fire suppression capability is functional to all areas on the 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.

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.

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.

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 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 CO_2 suppression systems, these dampers also close during the 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 <u>Safe-Shutdown Capability</u>

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 subdivide 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.

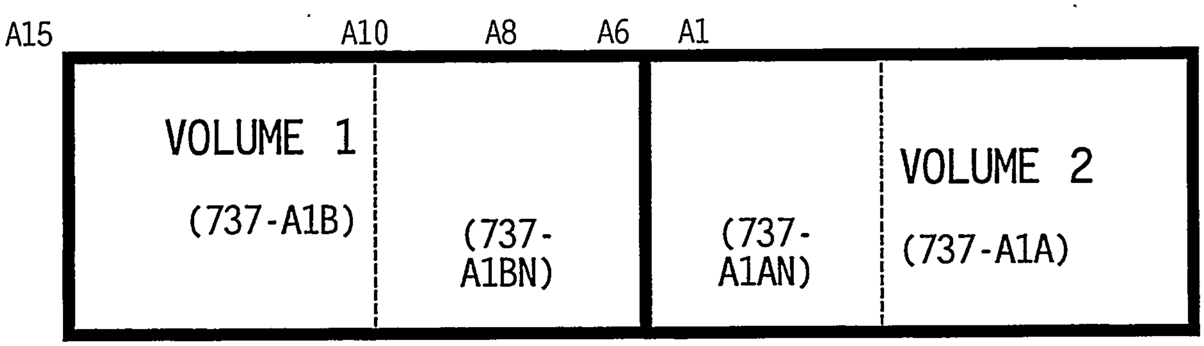

Figure 1

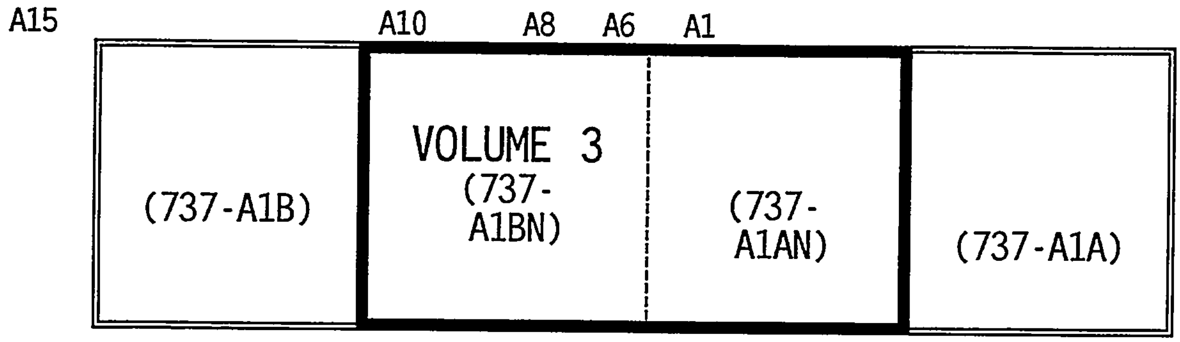

Figure 2

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.

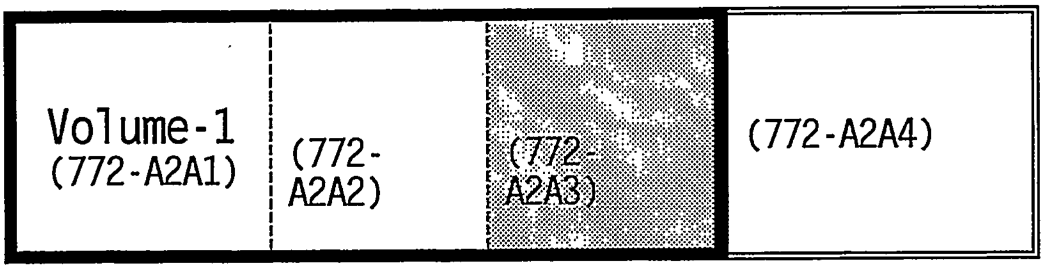

Figure 3

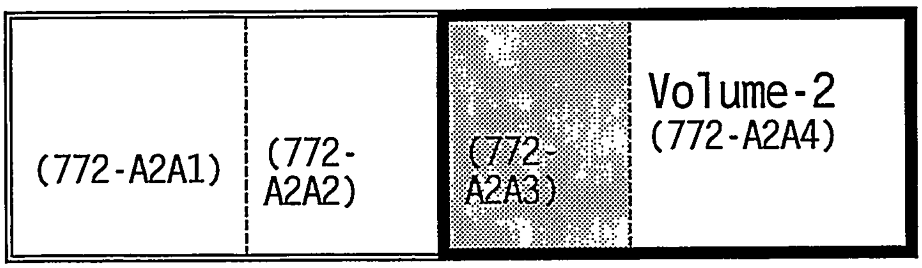

Figure 4

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 Ccoling 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.

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 Fire Barriers Used To Separate Redundant Safe-Shutdown Functions Within the Same Fire Area

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-inchdiameter 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.

Test Assembly 1-2 - Description

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.

<u>Test Assembly 1-6 - Description</u>

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

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

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 trowel-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 ½-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 Unistrut 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.

Test Assembly 2-6 - Description

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

Test Assembly 3-1 - Description

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.

<u>Test Assembly 3-2 - Description</u>

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.

Configuration 7: 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.

Configuration 8: 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 Δ
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 preformed 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 1¼-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 0-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 CO_2 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 achieve a 30-percent concentration within 2 minutes and 50-percent concentration within 7 minutes after system discharge. 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 reenforced 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 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 <u>Other Plant Areas</u>

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 <u>Deviation - Partial Fire Wall Between Component Cooling Water System Pumps</u>

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 <u>Deviation - Emergency Lighting</u>

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 <u>Deviation - Lack of Total Area Suppression and Detection</u>

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 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 basie 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 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.: 11210-94554a TEST DATE: 12/21/92	THERMAL PERFORMANCE CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 85°F MAX. AVG. TEMP. = 318°F MAX. SINGLE POINT TEMP. = 390°F FIRE RATING PERIOD: 1-HOUR				BARRIER CONDITION		REMARKS
	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		UNSAT BURNTHROUGH = BDT HOSE STREAM BREACH = HSB JOINT/SEAM FAILURE = JSF	SAT	
5" DIA. STEEL CONDUIT (5/8" BASE W/MESH/TROWEL-GRADE)	AVG 242	MAX 297	AVG 297	MAX 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	475	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 = 61°F MAX. AVG. TEMP. = 311°F MAX. SINGLE POINT TEMP. = 386°F 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 REPORT NO.: 11210-94554a TEST DATE: 3/31/93	THERMAL PERFORMANCE				BARRIER CONDITION		REMARKS
	CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 76°F MAX. AVG. TEMP. = 326°F MAX. SINGLE POINT TEMP. = 401°F 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				
1" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)	AVG 228	MAX 252	AVG 223	MAX 236		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 REPORT NO. 11210-94554b TEST DATE: 4/1/93	CONDITIONS OF ACCEPTANCE INITIAL TEMPERATURE = 75°F MAX. AVG. TEMP. = 325°F MAX. SINGLE POINT TEMP. = 400°F FIRE RATING PERIOD: 1-HOUR				BARRIER CONDITION		
					UNSAT	SAT	
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR				
3" STEEL CONDUIT	AVG 349	MAX 407	AVG 327	MAX 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 REPORT NO.: 11210-94554d TEST DATE: 4/6/93	THERMAL PERFORMANCE						BARRIER CONDITION		REMARKS
	CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 73°F MAX. AVG. TEMP. = 323°F MAX. SINGLE POINT TEMP. = 398°F 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				
1" STEEL CONDUIT (5/8" BASE WITH 3/8" OVERLAY)	AVG 218	MAX 223	AVG 212	MAX 219	AVG	MAX		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	
5" 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 = 72°F MAX. AVG. TEMP. = 322°F MAX. SINGLE POINT TEMP. = 397°F FIRE RATING PERIOD: 1-HOUR						BARRIER CONDITION		
SPECIMENS	EXTERIOR RACEWAY SURFACE		INTERNAL 8 AWG COPPER CONDUCTOR		JUNCTION BOX SURFACE		UNSAT	SAT	
4" STEEL CONDUIT - 5/8" BASE	AVG 271	MAX 322	AVG 219	MAX 287	AVG	MAX		SAT	ALL TEST SPECIMENS MET THE TEST ACCEPTANCE CRITERIA.
4" STEEL CONDUIT - 5/8" BASE	261	316	215	265				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 CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 83 °F MAX. AVG. TEMP. = 333 °F MAX. SINGLE POINT TEMP. = 408 °F FIRE RATING PERIOD: 1-HOUR												BARRIER CONDITION		REMARKS
													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)	306	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 (°F) INITIAL TEMPERATURE = 82 °F MAX. AVG. TEMPERATURE = 332 °F MAX. SINGLE POINT TEMPERATURE = 402 °F FIRE RATING PERIOD: 1-HOUR														BARRIER CONDITION		REMARKS
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.: 11960-97167 TEST DATE: 09/20/94	THERMAL PERFORMANCE										BARRIER CONDITION		REMARKS
	CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 78 °F MAX. AVG. TEMPERATURE = 328 °F MAX. SINGLE POINT TEMPERATURE = 403 °F FIRE RATING PERIOD: 1-HOUR										UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH = HSB JOINT/SEAM FAILURE = JSF	SAT	
SPECIMENS	FRONT TRAY SIDE RAIL		REAR TRAY SIDE RAIL		BELOW RUNGS		ON RUNGS		INSIDE AIR DROP				
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
COMMON ENCLOSURE (3-18" CABLE TRAYS) A. TOP TRAY	264	301	277	318			272	344				SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA
B. MIDDLE TRAY	265	321	263	343			271	343					
C. BOTTOM TRAY	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	CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 78 °F MAX. AVG. TEMPERATURE = 328 °F MAX. SINGLE POINT TEMP. = 403 °F FIRE RATING PERIOD: 1-HOUR														BARRIER CONDITION		REMARKS
SPECIMENS	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 223	MAX 284	AVG 142	MAX 188	AVG 142	MAX 180	AVG 132	MAX 175	AVG 129	MAX 166	AVG	MAX	AVG	MAX		SAT	SPECIMENS MET TEST ACCEPTANCE CRITERIA
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 REPORT NO.: 11960-97258 TEST DATE: 10/27/94	THERMAL PERFORMANCE CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 62 °F MAX. AVG. TEMPERATURE = 312 °F MAX. SINGLE POINT TEMPERATURE = 387 °F FIRE RATING PERIOD: 1-HOUR								BARRIER CONDITION UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH = HSB JOINT/SEAM FAILURE = JSF	BARRIER CONDITION SAT	REMARKS
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 2½", 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 (°F) INITIAL TEMPERATURE = 78 °F MAX. AVG. TEMPERATURE = 328 °F MAX. SINGLE POINT TEMPERATURE = 403 °F 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 (°F) INITIAL TEMPERATURE = 80 °F MAX. AVG. TEMPERATURE = 330 °F MAX. SINGLE POINT TEMPERATURE = 405 °F 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				
SEVEN 4" DIAMETER STEEL CONDUITS IN A COMMON ENCLOSURE.	AVG 228	MAX 287	AVG 212	MAX 237	AVG 230	MAX 286	AVG	MAX	AVG	MAX		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 REPORT NO.: 11960-97555 TEST DATE: 12/15/94	THERMAL PERFORMANCE CONDITIONS OF ACCEPTANCE (°F) INITIAL TEMPERATURE = 68 °F MAX. AVG. TEMP. = 318 °F MAX. SINGLE POINT TEMP. = 393 °F FIRE RATING PERIOD: 3 HOURS								BARRIER CONDITION UNSAT BURNTHROUGH = BBT HOSE STREAM BREACH = HSB JOINT/SEAM FAILURE = JSF	BARRIER CONDITION SAT	REMARKS
SPECIMENS	LEFT RAIL		RIGHT RAIL		TOP OF RAIL		JUNCTION BOX SURFACE				
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
12" WIDE STEEL CABLE TRAY	228	238	230	244	222	229				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 (°F) INITIAL TEMPERATURE = 64 °F MAX. AVG. TEMPERATURE = 314 °F MAX. SINGLE POINT TEMPERATURE = 389 °F FIRE RATING PERIOD: 3 HOURS										BARRIER CONDITION		
SPECIMENS	LEFT RAIL		RIGHT RAIL		TOP OF RUNGS		CONDUIT SURFACE		INSIDE CONDUIT OR AIR DROP		UNSAT	SAT	
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX			
12" WIDE STEEL CABLE TRAY	251	272	251	271	247	261						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
90° 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
90° 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
30"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 ° 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 ° 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.

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC. Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG-0847
Supplement No. 18

2. TITLE AND SUBTITLE

Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2

3. DATE REPORT PUBLISHED

MONTH	YEAR
October	1995

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

Peter S. Tam et al.

6. TYPE OF REPORT

Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION – NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

9. SPONSORING ORGANIZATION – NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Same as 8. above.

10. SUPPLEMENTARY NOTES

Docket Nos. 50-390 and 50-391

11. ABSTRACT *(200 words or less)*

Supplement No. 18 to the Safety Evaluation Report for the application filed by the Tennessee Valley Authority for license to operate Watts Bar Nuclear Plant, Units 1 and 2, Docket Nos. 50-390 and 50-391, located in Rhea County Tennessee, has been prepared by the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission, The purpose of this supplement is to update the Safety Evaluation with (1) additional information submitted by the applicant since Supplement No. 17 was issued, and (2) matters that the staff had under review when Supplement No. 17 was issued.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Safety Evaluation Report (SER)
Watts Bar Nuclear Plant
Docket Nos. 50-390/50-391

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page) Unclassified

(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE