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Safety Evaluation Report

on Tennessee Valley Authority: Browns Ferry Nuclear Performance Plan

Browns Ferry Unit 2 Restart

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

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ABSTRACT

This safety evaluation report (SER) was prepared by the U.S. Nuclear Regulatory Commission (NRC) staff and represents the second and last supplement (SSER 2) to the staff's original SER published as Volume 3 of NUREG-1232 in April 1989. Supplement 1 of Volume 3 of NUREG-1232 (SSER 1) was published in October 1989. Like its predecessors, SSER 2 is composed of numerous safety evaluations by the staff regarding specific elements contained in the Browns Ferry Nuclear Performance Plan (BFNPP), Volume 3 (up to and including Revision 2), submitted by the Tennessee Valley Authority (TVA) for the Browns Ferry Nuclear Plant (BFN). The Browns Ferry Nuclear Plant consists of three boiling-water reactors (BWRs) at a site in Limestone County, Alabama. The BFNPP describes the corrective action plans and commitments made by TVA to resolve deficiencies with its nuclear programs before the startup of Unit 2. The staff has inspected and will continue to inspect TVA's implementation of these BFNPP corrective action plans that address staff concerns about TVA's nuclear programs. SSER 2 documents the NRC staff's safety evaluations and conclusions for those elements of the BFNPP that were not previously addressed by the staff or that remained open as a result of unresolved issues identified by the staff in previous SERs and inspections.

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ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
ADS	automatic depressurization system
AISC	American Institute of Steel Construction
ALARA	as low as is reasonably achievable
ANSI	American National Standards Institute
AOI	abnormal operating instruction
APS	auxiliary power system
ARP	accelerated requalification program
ARS	amplified response spectrum/spectra
ASME	American Society of Mechanical Engineers
AUO	Auxiliary Unit Operator
BFN	Browns Ferry Nuclear Plant
BFNPP	Browns Ferry Nuclear Performance Plan
BWR	boiling-water reactor
BWROG	Boiling Water Reactor Owners Group
CAL	confirmatory action letter
CAQR	condition adverse to quality report
CATD	corrective action tracking document
CEG	Contractor Engineering Group
CFR	Code of Federal Regulations
CNPP	Corporate Nuclear Performance Plan
CRD	control rod drive
CREVS	control room emergency ventilation system
DBA	design-basis accident
DBE	design-basis earthquake
DBVP	design baseline and verification program
DCRDR	detailed control room design review
DG	diesel generator
DGB	diesel generator building
DNE	Division of Nuclear Engineering (TVA)
DOL	Department of Labor, U.S.
DS	design standard
EA	enforcement action
ECCS	emergency core cooling system
ECN	engineering change notice
ECP	Employee Concerns Program
ECSP	Employee Concerns Special Program
EDG	emergency diesel generator
EDO	Executive Director for Operations (NRC)
EECW	emergency equipment cooling water
EOI	emergency operating instruction
EOP	emergency operating procedure
EPRI	Electric Power Research Institute

EQ	equipment qualification
ERT	Employee Response Team
FSAR	Final Safety Analysis Report
GDC	general design criterion/criteria
GE	General Electric Company
GIP	generic implementation procedure
GL	generic letter
GOI	general operating instruction
HED	human engineering deficiency
H&I	harassment and intimidation
HPFP	high-pressure fire protection
HVAC	heating, ventilation, and air conditioning
IE	Office of Inspection and Enforcement (NRC)
IEB	IE bulletin
IEG	Items Evaluation Group
IFI	inspector followup item
IGSCC	intergranular stress corrosion cracking
IHSI	induction heating stress improvement
IN	information notice
INPO	Institute of Nuclear Power Operations
IPE	individual plant examination
IR	inspection report
ISI	inservice inspection
LCO	limiting condition(s) for operation
LER	licensee event report
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LPCI	low-pressure coolant injection
MAP	Maintenance Action Plan
MCC	motor control center
MELB	moderate-energy line break
MIC	microbiologically induced corrosion
MIP	Maintenance Improvement Program
MSA	management self-assessment
MTI	maintenance team inspection
NCR	nonconforming condition report
NDE	nondestructive examination
NE	nuclear engineering
NFPA	National Fire Protection Association
NMRG	Nuclear Managers Review Group (TVA)
NOI	notice of indication
NP	nuclear power
NQAM	Nuclear Quality Assurance Manual
NQAP	Nuclear Quality Assurance Plan

NRC	Nuclear Regulatory Commission, U.S.
NRR	Office of Nuclear Reactor Regulation (NRC)
NSSS	nuclear steam supply system
NUCPR	nuclear procedure requirement
OBE	operating-basis earthquake
OEP	Office of Engineering Procedures (TVA)
OGTB	off-gas treatment building
OI	operating instruction
ONP	Office of Nuclear Power (TVA)
ORAT	Operational Readiness Assessment Team
ORR	Operational Readiness Review
OSIL	Operations Section Instruction Letter
PASS	post-accident sampling system
PCR	Procedure Change Request
PMI	plant manager instruction
PMP	Program Manual Procedure
PRA	probabilistic risk assessment
PSD	power spectral density
PSI	preservice inspection
QA	quality assurance
QC	quality control
QTC	Quality Technology Company
QVI	quality verification inspection
RG	regulatory guide
RHR	residual heat removal
RHRSW	residual heat removal service water
RPIP	Regulatory Performance Improvement Program
RPV	reactor pressure vessel
RSW	raw service water
RT	radiographic test
RTP	restart test program
RWCU	reactor water cleanup system
SAIC	Science Applications International Corporation
SALP	systematic assessment of licensee performance
SD	standard drawing
SDSP	Site Director Standard Practice
SER	safety evaluation report
SGTB	standby gas treatment building
SGTS	standby gas treatment system
SI	surveillance instruction
SLC	standby liquid control
SMART	Senior Management Assessment of Readiness Team
SNL	Sandia National Laboratories
SOS	Shift Operations Supervisor
SPDS	safety parameter display system
SPOC	system preoperability checklist

SQN	Sequoyah Nuclear Plant
SQUG	Seismic Qualification Utility Group
SRN	specification revision notice
SRO	Senior Reactor Operator
SRP	Standard Review Plan
SRSS	square-root-of-the-sum-of-the-squares technique
SSE	safe-shutdown earthquake
SSER	supplement to safety evaluation report
SSFI	safety system(s) functional inspection
SSQE	safety system(s) quality evaluation
SSS	Shift Support Supervisor
ST	special test
STA	Shift Technical Advisor
SWEC	Stone and Webster Engineering Corporation
TS	Technical Specification
TS&M	technical staff and managers
TSM-O	technical staff and managers orientation
TVA	Tennessee Valley Authority
URI	unresolved item
USI	unresolved safety issue
USQD	unresolved safety question determination
WBN	Watts Bar Nuclear Plant
WP	welding project
ZPA	zero period acceleration

1 INTRODUCTION

On September 17, 1985, the Executive Director for Operations (EDO) of the U.S. Nuclear Regulatory Commission (NRC) issued a letter to the Chairman of the Board of Directors of the Tennessee Valley Authority (TVA or the licensee) pursuant to Title 10 of the Code of Federal Regulations, Section 50.54(f) [10 CFR 50.54(f)], requesting information on the actions the licensee was taking to resolve NRC's concerns about TVA's nuclear power program. These concerns were divided into four categories: (1) corporate activities, (2) the Sequoyah Nuclear Plant, (3) the Browns Ferry Nuclear Plant, and (4) the Watts Bar Nuclear Plant. A summary of the concerns raised in the staff's 10 CFR 50.54(f) letter and the status of the resolution of these concerns are contained in Appendix C to Volume 3, NUREG-1232, issued April 1989.

TVA's Corporate Nuclear Performance Plan (CNPP), which was prepared in response to the NRC letter, was submitted to the NRC on November 1, 1985. (See Table 1.1 for issue dates of Volume 1 and its revisions.) The NRC staff's safety evaluation of the revised CNPP, through Revision 4, was issued in July 1987 as NUREG-1232, Volume 1, "Safety Evaluation Report on Tennessee Valley Authority."

In addition to its corporate plan, TVA prepared separate plans to address site-specific problems at each of its nuclear plants. Volume 3 of NUREG-1232 and its supplements constitute a compilation of NRC safety evaluation reports (SERs) regarding the corrective actions planned and implemented by TVA in accordance with the Browns Ferry Nuclear Performance Plan (BFNPP), Volume 3 (Rev. 2), tailored specifically for restart of Unit 2. (See Table 1.1 for issue dates of Volume 3 of the BFNPP and its revisions.) In many cases, long-term corrective action plans extending beyond restart of Unit 2 were required to fully resolve the issues identified in the staff's letter. TVA's BFNPP described these plans in great detail. The Browns Ferry Nuclear Plant (BFN) consists of three boiling-water reactors at a site in Limestone County, Alabama.

Regulatory performance at Browns Ferry had declined during the years preceding the submittal of the BFNPP. Evaluations by TVA, contractors engaged by TVA, and the NRC staff pointed out many specific deficiencies in plant performance.

The root causes of these deficiencies and the actions taken at the TVA corporate level to correct them are described in Volume 1, Revision 6, of the CNPP. These actions included (1) hiring, developing, and retaining experienced nuclear managers; (2) restructuring the nuclear organization to clarify lines of authority and responsibility and to provide centralized direction and control of nuclear activities; (3) taking steps to restore the employee's trust in nuclear management; (4) increasing upper management's awareness of, and involvement in, nuclear activities; and (5) improving the nuclear management systems and controls, the nuclear corrective action program, and other program areas of operation, maintenance, welding, design change, and plant modification.

This study of root causes and corrective actions extended to BFN site operations. Corrective initiatives started at the corporate level have been implemented by the BFN site director as well as through offsite organizations responsible for direct support. These improvements included (1) organizational changes compatible with the restructuring of TVA's nuclear power organization, (2) improved management control and involvement, (3) revised conduct of operations and maintenance activities, (4) improved quality awareness, (5) centralized design control, (6) a long-term program for upgrading procedures, and (7) programs to restore employee confidence.

TVA conducted a close, critical review of the problems and issues identified at Browns Ferry and determined that the difficulties at this plant stemmed from three basic causes (BFNPP, Section I.4.0):

- Lack of clear assignment of responsibility and authority to managers and their organizations that clearly established accountability for performance

- Insufficient management involvement and control in the workplace, leading to a failure to adequately establish the highest quality of performance

- Failure to maintain consistently a documented design basis for the plant and to control consistently the plant's configuration in accordance with that basis

As a consequence, principal functional areas of plant activities required strengthening on a long-term, continuing basis. These areas involved operations, maintenance, surveillance, radiological controls, chemistry, security, emergency preparedness, and site scheduling. These areas cover the functional areas normally reviewed in either the Institute of Nuclear Power Operations (INPO) evaluations or NRC systematic assessment of licensee performance (SALP) reports.

Special programs were defined by TVA in a number of areas to ensure that integrated corrective action plans would deal with problems created by deficiencies in the past conduct of activities. The following special programs were identified as requiring resolution before restart of Unit 2 (BFNPP, Sections II and III):

(1) Establish environmental qualification of safety-related electrical equipment.

(2) Establish and maintain a documented design basis.

(3) Review suspended components for structural adequacy during a seismic design-basis event.

(4) Review electrical, mechanical, nuclear, and civil design calculations for adequacy.

(5) Review fire protection with respect to current NRC and general industrial requirements and recommendations.

(6) Review past welding practices and installed welds for adequacy.

(7) Review the current condition of the primary system pressure boundary and other structural components for adequacy relative to intergranular stress corrosion cracking.

(8) Establish coordinated restart test and operational readiness programs.

(9) Review installations of safety-related instrument-sensing lines for slope, separation, material control, fabrication, and quality assurance.

(10) Inspect suspect areas of piping to ensure that wall loss as a result of erosion and/or corrosion does not exceed allowable limits.

(11) Develop a summary document that describes changes made in the Browns Ferry probabilistic risk assessment (PRA) and the bases for concluding that the revised PRA conservatively reflects the Browns Ferry configuration.

(12) Review piece-part procurement to ensure that qualification of safety-related equipment is maintained.

(13) Review electrical installations to ensure functionality to mitigate design-basis events described in Chapter 14 of the Final Safety Analysis Report (FSAR) and provide for safe shutdown.

Of the programs mentioned above, items 1, 2, 3, 4, 5, 6, 7, 8, 10, and 11 were evaluated in Chapters 2 through 4 of the SER, NUREG-1232, Volume 3, issued April 1989, and Supplement 1 to the SER (SSER 1), dated October 1989. Supplement 2 (SSER 2) completes the staff's evaluations of the programs listed above.

In addition to the special programs identified above, the staff also evaluated in SSER 2 other important activities and programs not evaluated in previous SERs that are part of the corrective action plans of the BFNPP, such as the Q-List Program, containment coatings, platform thermal growth, cable splices, heat code traceability, operations, flex conduits, ampacity, procedures upgrading, diesel generators, and site management. Most of these activities, including the special programs, will be applicable to all three BFN units. However, TVA and NRC must ultimately determine the applicability of these programs specifically for Units 1 and 3. Consequently, the staff's evaluations of the BFNPP conducted to date apply almost exclusively for restart of BFN Unit 2.

One of the major problem areas addressed in the BFNPP included the concerns expressed by TVA employees regarding the quality of TVA's nuclear activities. The staff's evaluation of TVA programs to reconcile employee concerns is summarized in Chapter 5 of SSER 2.

The status of the staff's evaluations of allegations is summarized in Chapter 6 of SSER 2.

Together with Volume 3 of NUREG-1232 and SSER 1, SSER 2 contains the staff's SERs for all safety-significant activities and program areas described in the BFNPP, through Revision 2, including related supporting documentation. Although not intended to stand alone, SSER 2 does reiterate in compendium form, either for completeness or as background text to support new conclusions, some conclusions documented in previous SERs contained in Volume 3 of NUREG-1232 and SSER 1. Appendix B of SSER 2 provides a list of all significant NRC and TVA documents referenced by this SSER.

More specifically, the primary purpose and intent of SSER 2 are to accomplish the following: (1) document the staff's SERs for all significant program areas of the BFNPP not previously addressed in Volume 3 of NUREG-1232 and SSER 1;

(2) document resolution of outstanding restart issues for BFN Unit 2 raised by Volume 3 of NUREG-1232 and SSER 1; (3) identify all Unit 2 restart issues that remain open, if any, from Volume 3 of NUREG-1232 and SSER 1 and describe what actions by TVA or NRC are necessary to resolve them; and (4) revise as necessary any previous staff SERs affected by changes to TVA's programs since Volume 3 of NUREG-1232 and SSER 1 were published.

In addition to documenting the many multidisciplinary safety evaluations performed by the staff, SSER 2 also summarizes the results and/or status of related staff inspection efforts. In its total review of TVA's BFNPP, the staff not only performed an evaluation of each safety-significant corrective action program but also conducted inspections to confirm that these programs were adequately implemented. Appendix F to SSER 2 provides a list of the more significant inspections conducted to date involving the BFNPP.

Thierry M. Ross, NRC Project Manager for Browns Ferry, was the primary staff member responsible for developing SSER 2 and in coordinating the NRC resources involved with preparing the SERs contained herein. Appendix A provides a list of the principal staff technical contributors. For additional information or questions regarding this or previous staff publications related to Browns Ferry, please contact Mr. Ross by telephone at (301) 492-7000 or by writing to:

Mr. Thierry M. Ross
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Table 1.1 Issue dates of Tennessee Valley Authority Nuclear Performance Plan and revisions

Publication	Date of issue
Volume 1: Corporate Nuclear Performance Plan (CNPP)	
Original	November 1, 1985
Revised (original)	March 10, 1986
Revision 1	July 17, 1986
Revision 2	July 31, 1986
Revision 3	December 4, 1986
Revision 4	March 26, 1987
Revision 5	December 10, 1987
Revision 6	May 5, 1989
(Volume 2 applies only to the Sequoyah Nuclear Plant)	
Volume 3: Browns Ferry Nuclear Performance Plan (BFNPP)	
Original (Revision 0)	August 28, 1986
Revision 1	July 1, 1987
Revision 2	October 24, 1988

2 ADEQUACY OF DESIGN

2.1 Configuration Management Program, Design Baseline and Verification Program, and Design Calculations Program

In Section 2.1 of Volume 3 of NUREG-1232, the NRC staff evaluated the configuration management program, the design baseline and verification program (DBVP), and the design calculations program for BFN Unit 2, as described in TVA's BFNPP and related supporting documents. In Volume 3 of NUREG-1232, the NRC staff concluded that TVA had adequately identified the problems associated with design control and design control changes and had instituted an appropriate design-basis and verification program to reestablish the design basis and to ensure that the plant configuration conformed with its design basis. The staff also concluded that the DBVP, if properly implemented, would ensure that the functional plant configuration is reflected in design documents and drawings, and thus provide confidence that systems required for safe shutdown of the plant can perform their safety-related functions.

TVA is implementing the Browns Ferry DBVP in two phases: Phase I will be completed before startup and will include the evaluation of systems and portions of systems required for safe shutdown. These systems will be identified by evaluating the abnormal operational transients, design-basis accidents, and special events addressed in Chapter 14 of the Browns Ferry FSAR and by determining the safety functions necessary to mitigate these events. Phase II will be completed after startup and will include implementation of the remaining modifications of systems not required for startup, completion and revision of the design criteria documentation, completion of system evaluations, and implementation of corrective actions on other systems as required. TVA is to formally notify the staff when Phase I is complete.

At this juncture, no outstanding programmatic issues must be resolved before the restart of Unit 2. In addition, the staff has conducted numerous individual and team inspections to verify that TVA was implementing these programs in a satisfactory manner. A list of the more significant NRC inspections can be found in Appendix F to this supplement.

A final team inspection of the DBVP was conducted from February 27 through March 10, 1989, as documented by NRC Inspection Report (IR) 50-259/89-07, 50-260/89-07, and 50-296/89-07, dated June 30, 1989. In addition to following up on open items identified during previous inspections, the purpose of this team inspection was to review and assess overall adequacy of TVA's implementation of the DBVP at BFN. By the end of this inspection, the NRC team had not discovered any significant discrepancies in TVA's implementation of the DBVP requirements. Most of the discrepancies found by the staff had been previously identified by TVA, and the associated corrective actions were being tracked on a checklist report. The NRC inspection team therefore concluded that TVA, in general, was adequately implementing the DBVP at BFN for those essential systems required to safely shut down the plant. The team also concluded that upon TVA's successful completion of the DBVP, BFN Unit 2 will be in conformance with its design basis. On August 22, 1989, TVA responded to the inspection findings of the team's IR 50-259, 260, 296/89-07 regarding minor weaknesses in TVA's implementation of the DBVP. The NRC staff reviewed TVA's response and determined that it acceptably addresses these inspection findings.

However, additional open restart inspection items regarding the aforementioned programs were found by the in-depth "vertical slice" team inspection of the core spray system conducted during the weeks of November 27 and December 11, 1989, at the BFN site. This inspection included the DBVP, applicable engineering design calculations, and configuration control implemented by TVA for the core spray system. The results of this inspection, as documented by IR 50-259, 260, 296/89-16, dated March 9, 1990, identified specific problems with TVA's engineering calculations. The staff concluded in its inspection report that TVA's program for controlling these calculations requires additional corrective actions by TVA. The staff conducted a followup inspection in November 1990 to assess the effectiveness of TVA's corrective actions for controlling design calculations. This inspection was documented in IR 50-259, 260, and 296/90-33, which concluded that TVA's corrective actions were generally adequate, but the staff was still concerned about the control of design inputs for calculations. The NRC will conduct another followup inspection before restart to resolve this residual concern.

It should be noted that eight post-restart action items were identified by the staff's special onsite inspection of the BFN Civil Calculation Review Program (see IR 50-260/89-42).

2.2 Seismic Design Issues

As a result of different programs conducted by the licensee for the Browns Ferry Nuclear Plant, Units 1, 2, and 3, and several inspections conducted by the NRC staff, a number of concerns were raised at Browns Ferry regarding the structural design adequacy of safety-related suspended systems. These concerns encompass structural response to different loadings, including dead load, live load, pressure, and temperature, as well as seismic load. Among the root causes of these concerns are a lack of attention by the licensee to design details when implementing modifications, a weakness in the licensee's quality control that resulted in failures to identify and adequately track variances, and the failure of the licensee to maintain seismic design criteria records for the original design.

In order to produce new design records for the plant and to improve the plant condition as necessary, the licensee initiated and submitted various programs, as described in Volume 3 of the BFNPP, to correct deficiencies and to resolve identified concerns. The seismic design program (BFNPP, Section III.3.0) was one of these programs.

The seismic design program originally covered design areas 1 through 14. To ensure that proper input ground motion was used for the analysis of structures and subsystems (piping and components), TVA was requested to address three additional design areas, 15 through 17.

(1) Large-bore piping and supports
(2) Small-bore piping and supports
(3) Torus piping (both internal and external)
(4) Control rod drive (CRD) piping and supports

(5) Instrument tubing
(6) Cable tray and supports
(7) Electrical conduit and supports
(8) Heating, ventilation, and air conditioning (HVAC) ductwork and supports
(9) Drywell steel platforms
(10) Miscellaneous steel
(11) Torus structure (including internal)
(12) Mechanical and electrical equipment
(13) Effect of the failures of seismic Class II features on seismic Class I systems
(14) Secondary containment penetrations
(15) Seismic ground motion
(16) Dynamic analysis of Class I structures
(17) Generation of amplified response spectra (ARS)

On the basis of their characteristics and resolution status, these 17 design areas are discussed in 4 subsections of SSER 2. The earthquake ground motion at the Browns Ferry site (design area 15) is covered in Section 2.2.1. This ground motion is to be used as the input motion for the dynamic analysis of structures. Design areas 6, 7, 8, 9, 10, 14, 16, and 17 are categorized as civil/structural issues and are discussed in Section 2.2.2. All piping-related areas, that is design areas 1, 2, 4, and 5, are discussed in Section 2.2.3. The remaining design areas, 3, 11, 12, and 13, are covered in Section 2.2.4. All 17 of these seismic design program areas have been examined in detail by numerous NRC inspections. A list of NRC inspections conducted to date, by subject area, is provided in Appendix F to this supplement.

2.2.1 Ground Motion

See NUREG-1232, Volume 3, SSER 1.

2.2.2 Civil/Structural Issues

See NUREG-1232, Volume 3, SSER 1.

2.2.2.1 Dynamic Analysis of Seismic Class I Structures

See NUREG-1232, Volume 3, SSER 1.

2.2.2.1.1 Modeling of Structures

See NUREG-1232, Volume 3, SSER 1.

2.2.2.1.2 Input Motion for Seismic Analysis

See NUREG-1232, Volume 3, SSER 1.

2.2.2.1.3 Seismic Analysis of Structures

See NUREG-1232, Volume 3, SSER 1.

2.2.2.2 Development of the Amplified Response Spectra

The original design amplified response spectra (ARS) were generated on the basis of a single-stick structural model and El Centro time-history as input. Peak broadening was not applied to these ARS. Because of the staff's concern about the adequacy of these ARS and the staff's acceptance of the use of artificial time-history for generating ARS, the licensee reanalyzed all seismic Class I structures and regenerated ARS for the analysis of the attached piping and components. The staff's review of the licensee's analytical approach and the resultant ARS raised three concerns: (1) the requirement of peak broadening, (2) the definition of zero period acceleration, and (3) the impact of the new ARS. The staff's review of the licensee's resolution of these three issues and the conclusions drawn are discussed below:

2.2.2.2.1 Requirement of Peak Broadening

See NUREG-1232, Volume 3, SSER 1.

2.2.2.2.2 Definition of Zero Period Acceleration for the New Amplified Response Spectra

See NUREG-1232, Volume 3, SSER 1.

2.2.2.2.3 Impact of New Amplified Response Spectra

In response to the staff's concerns regarding the impact of the new ARS discussed in Section 2.2.2.2.3 of SSER 1, TVA conducted an impact assessment program. This program addressed four issues: (1) the adequacy of the new ARS as input for the evaluation of structural elements and components, (2) the impact of the new ARS on the evaluation results completed by the licensee based on the original ARS, (3) reevaluation of the reactor building superstructures, and (4) reevaluation of the primary system. In SSER 1, the staff concluded that all aspects of the program were closed except two: (1) the impact of the new ARS on the evaluation completed previously by the licensee and (2) reevaluation of the primary system. During the last two NRC inspections of TVA's seismic design programs, as documented by IRs 50-260/89-42 and 50-260/89-62, dated February 26 and 16, 1990, respectively, these two issues were resolved and closed, along with the three open inspection items from IR 50-260/89-31, dated July 17, 1989, described in Section of 2.2.2.2.3 of SSER 1. However, IR 50-260/89-42 identified two additional open inspection items that must be addressed before restart of Browns Ferry Unit 2. The staff requested TVA to resolve these two open items as follows: (1) complete the final confirmatory evaluation for the two lower steel platforms inside the drywell when generation of the new pipe support loads from the NRC Office of Inspection and Enforcement (IE) Bulletin 79-14 program is finished and (2) complete the evaluation of ductwork (including supports) for heating, ventilation, and air conditioning (HVAC) inside the chimney. The staff also requested that TVA submit the results of these evaluations to NRC for review.

On May 11, 1990, TVA provided (for information only) calculations from its final impact evaluation of HVAC ductwork and supports inside the chimney to NRC. The staff reviewed this submittal and concluded in a SER dated August 22, 1990, that the new ARS impact evaluation performed by TVA for Class I ductwork and supports inside the chimney met the requirements for restart. Consequently, the only restart item left open at this time involves evaluation of the lower steel platforms in the drywell, as described above. TVA must document this evaluation and is requested to notify the staff when it is complete and available on site for staff review.

Regarding post-restart actions, six items remain open:

(1) For lower drywell platforms, TVA should evaluate and upgrade, as needed, those structural steel elements, connections, and anchorages qualified to the interim criteria against the long-term criteria (IR 50-260/89-42).

(2) For miscellaneous steel frames, TVA should evaluate and upgrade, as needed, the structural steel elements, base plates, connections, and anchorages qualified to the interim criteria against the long-term design criteria (IR 50-260/89-42).

(3) For HVAC ductwork and supports, TVA should conduct the long-term modifications for System 36 in the diesel generator building and System 41 in the standby gas treatment building that were qualified to the interim criteria (IR 50-260/89-42).

(4) For HVAC ductwork and supports, TVA should complete the long-term evaluation of the impact of the new ARS on the Class I ductwork in the chimney and modify the ductwork as needed (IR 50-260/89-42).

(5) TVA should finalize the evaluation method documents for the nuclear steam supply system (NSSS) components (IR 50-260/89-39).

(6) For all commodities, TVA should demonstrate compliance of the long-term design criteria with the FSAR requirements (IR 50-260/89-42).

TVA is requested to resolve these issues after restart of Unit 2 and to submit the results of its evaluations and modifications to NRC for review.

2.2.2.3 Electrical Conduit and Supports

As documented in SSER 1, two restart items remained open in this design area: (1) evaluation of support rod hangers and (2) evaluation of conduit with Unistrut supports. On the basis of the results of the last NRC inspection conducted on TVA's seismic design program (IR 50-260/89-42), these two issues were resolved and closed. However, regarding post-restart actions, two items remain open:

(1) TVA should evaluate and upgrade, as needed, the aluminum conduit and supports qualified to the interim criteria against Unresolved Safety Issue (USI) A-46 program guidelines (IR 50-260/89-29).

(2) TVA should evaluate and upgrade, as needed, the steel conduit and supports qualified to the interim criteria against USI A-46 program guidelines (IR 50-260/89-29).

The staff will follow up TVA's resolution of these two items.

2.2.2.4 Heating, Ventilation, and Air Conditioning Ductwork and Supports

According to SSER 1, only one restart item, buckling of ductwork, remained open. On the basis of the results of the last NRC inspection of TVA's seismic design program (IR 50-260/89-42), this item was resolved and closed.

However, regarding post-restart actions, IR 50-260/89-42 identified three open items:

(1) TVA should evaluate and identify the need for long-term modification of the approximate 11,830 feet of ductwork that met the interim criteria (IR 50-260/88-38).

(2) TVA should perform the long-term modification of the 509 existing supports that were qualified to the interim criteria (IR 50-260/88-38).

(3) TVA should develop long-term criteria for HVAC evaluation and perform long-term buckling evaluation for all ductwork qualified to the interim criteria (IR 50-260/89-42).

TVA is requested to resolve these issues after restart and to submit the results of these evaluations and/or modifications to NRC for review.

2.2.2.5 Drywell Access Platforms

SSER 1 identified the following four restart items as open: (1) assumption of rigid lower platforms in the horizontal direction, (2) equivalent static analysis of drywell platforms, (3) platform clip angle criteria, and (4) use of the factor "1.33" to increase the allowable stress. During the last two NRC inspections of TVA's seismic design programs (IRs 50-260/89-32 and 50-260/89-42), these four issues were resolved and closed. However, regarding post-restart actions, IR 50-260/89-42 identified one open item: TVA should evaluate and upgrade, as needed, those structural steel elements, base plates, connections, and anchors qualified to the interim criteria against the long-term criteria. TVA is requested to resolve this issue after restart of Unit 2 and to submit the results of this evaluation to NRC for review.

2.2.2.6 Miscellaneous Steel

As described in SSER 1, the only remaining restart open item involved a concern about design criteria and the percentage of work completed. During the NRC inspection conducted in August 1989 (IR 50-260/89-32), this issue was resolved and closed. Regarding post-restart actions, the staff SER of July 26, 1988, on TVA's evaluation criteria identified one open item: TVA should address the adequacy of using the 1978 edition of the American Institute of Steel Construction (AISC) Specifications in the restart evaluation in lieu of the 1963 edition specified in the FSAR. TVA is requested to resolve this issue after restart and submit the results of its evaluation to NRC for review.

2.2.2.7 Cable Tray and Supports

On the basis of the staff SER documented in SSER 1, TVA's interim acceptance evaluation for the Unit 2 cable tray/suppports was found to be acceptable.

The long-term (i.e., post-restart) evaluation of the Browns Ferry cable tray/support seismic qualification will be covered within the framework of the USI A-46 program.

2.2.2.8 Secondary Containment Penetrations

The program to upgrade the secondary containment penetrations was evaluated by the staff, as documented in SSER 1. In SSER 1, the staff concluded that TVA's program for sealing the penetrations to bring the Browns Ferry secondary containment into conformance with the original Final Safety Analysis Report (FSAR) design was acceptable. However, to satisfy its FSAR commitment, TVA had to demonstrate that the post-design-basis earthquake (DBE) configuration of the standby gas treatment system (SGTS) and the secondary containment would be capable (within the design-basis SGTS flow rate) of maintaining a negative quarter inch of water vacuum inside the secondary containment. By letter dated October 6, 1989, TVA confirmed that the design, testing, and modifications required to resolve this issue had been completed. Furthermore, TVA revised the FSAR to clarify design of the secondary containment in terms of this performance-based commitment to maintain its pressure boundary capability following a DBE. After reviewing this letter and Revision 7 of the updated FSAR, the staff concluded that the actions taken by TVA were sufficient to permit the SGTS and the secondary containment at BFN Unit 2 to accomplish their intended safety function (i.e., maintain a quarter inch of water vacuum) as described in the FSAR, and thus prevent unfiltered radiological releases to the environment. Therefore, the staff considers this restart issue from SSER 1 to be closed.

2.2.3 Piping Issues

Section III.3 of the BFNPP describes four separate TVA programs that address seismic Class I (safety-related) piping at Browns Ferry. These programs are (1) the torus attached piping program, (2) the IE Bulletin 79-14/79-02 program, (3) the CRD insert and withdrawal piping program, and (4) the small-bore piping program. In addition, TVA has developed another program to address seismic Class I instrument tubing. This program is discussed in the section on small-bore piping in the BFNPP. These programs cover the entire scope of seismic Class I piping at Browns Ferry. All piping programs, with the exception of the torus attached piping program, use the same basic design criteria. These design criteria were discussed in great detail in the staff's evaluation of TVA's program for IE Bulletins 79-02 and 79-14 (see Section 2.2.3.1 of SSER 1). Torus attached piping was the subject of special design criteria provisions developed during resolution of the Mark I containment generic issue. These design provisions had been previously evaluated by the NRC staff and its consultants, and the results of this evaluation are documented in a staff SER transmitted to TVA by letter dated May 6, 1985.

TVA documented its completion of all work associated with torus attached piping as part of the Mark I Containment Long-Term Program for Unit 2 by letter dated October 2, 1990. Torus attached piping is discussed in Section 2.2.4.4 of SSER 1. For the remaining programs, TVA proposed to use restart criteria (interim operability criteria) to determine the modifications required before the restart of Unit 2. The staff concluded that the use of the restart criteria, as approved by the staff in a letter dated June 9, 1987, is acceptable for one cycle of Unit 2 operation.

TVA also proposed limiting the restart scope of the small-bore piping and instrument tubing programs to the restart boundary defined by the DBVP. For both of these programs, implementation of the DBVP resulted in an increase in the total program scope from TVA's original projections. The staff considers that the restart scope for these programs, if implemented consistent with TVA's commitments for the DBVP and the design calculation program, provides reasonable assurance of functionality of those systems to mitigate FSAR Chapter 14 events and provides for safe shutdown for at least one cycle of Unit 2 operation.

Additional staff evaluations of TVA's individual piping programs follow.

2.2.3.1 IE Bulletin 79-14/79-02 Program

The licensee's program to address concerns identified about past implementation of IE Bulletins 79-02 and 79-14 was evaluated in Section 2.2.3.1 of SSER 1. In SSER 1, the staff concluded that the licensee had defined an adequate program for resolving IE Bulletin 79-14/79-02 concerns. The staff further concluded that pending acceptable resolution of items identified in the pre-restart inspections, TVA's completion of the restart program will provide confidence that sufficient margins exist in the design of piping and supports within the scope of the program for Unit 2 restart. The staff had identified several open items concerning the licensee's design criteria, including the criteria used to identify required restart modifications, during an NRC team inspection (IR 50-260/89-15). The staff has since reviewed TVA's response to these open issues in two subsequent inspections and has documented the results in IRs 50-260/89-36 and 50-260/89-44. IR 50-260/89-36 documents the resolution of some of the design criteria items, including the criteria used to determine required restart modifications. IR 50-260/89-44 documents the staff's review of the remaining open items. IR 50-260/89-44 also documents the results of an NRC team inspection of TVA's implementation of the IE Bulletin 79-14/79-02 program. In IR 50-260/89-44, the staff identified 14 additional open items. Most of these open items involve deficiencies and concerns associated with program implementation. TVA has defined corrective actions to address these open items in a letter dated March 16, 1990. The staff documented its closure of all these outstanding inspection open items, except for one, in IR 50-259, 260, and 296/90-37. The final remaining open item regarding TVA's position concerning seismic classification of the reactor building closed cooling water system has been evaluated by the staff but will be documented in separate correspondence to TVA before restart of BFN Unit 2.

SSER 1 discussed the TVA's proposed use of time-history analysis for the design of piping as an alternative to the response spectra method of analysis. The staff concluded that the use of time-history analysis for piping seismic design requires further review and, if necessary, the establishment of additional criteria to be used on a case-by-case basis before its implementation. During the NRC team inspection of the implementation of the IE Bulletin 79-14/79-02 program (IR 50-260/89-44), TVA's use of time-history analysis for the qualification of the reactor recirculation system was also examined. As a result, another open item was identified. TVA's response to this open item in a letter dated March 16, 1990, stated that the piping had been qualified using the ARS method of analysis. Therefore, TVA did not use time-history analysis to qualify piping at BFN Unit 2. The staff's evaluation of the criteria for ARS is contained in Section 2.2.2.2 of SSER 1.

Section 2.2.3.1 of SSER 1 stated that final closeout of NRC reviews of TVA's field walkdown inspections in accordance with its programs to comply with IE Bulletins 79-02 and 79-14 would be documented in a future inspection report. The staff has performed two additional inspections of the TVA's field walkdown and support inspections and has documented the results in IRs 50-259, 260, 296/89-57 and 50-259, 260, 296/90-09. IR 50-259, 260, 296/89-57 identified a violation involving discrepancies between as-installed conditions and the drawings for pipe supports. IR 50-259, 260, 296/90-09 identified additional discrepancies. The staff will review TVA's corrective actions for this violation and document the results of the review in an inspection report.

2.2.3.2 Control Rod Drive Insert and Withdrawal Piping Program

Section 2.2.3.2 of SSER 1 summarizes the staff's evaluation of TVA's program to address the concern raised about the adequacy of the control rod drive (CRD) insert and withdrawal piping supports to sustain design-basis loads. In SSER 1, the NRC staff determined that the licensee had developed special provisions in the design criteria for combining multiple pipe loads on the CRD support frames. These special provisions in the design criteria included load factors to account for the phasing of loads from the individual insert and withdrawal lines on the support frames. The staff did not believe TVA's load factors were adequately justified (see NRC summary of a July 7, 1989, meeting, dated August 19, 1989). TVA subsequently developed a revised set of load factors on the basis of a comparison of the results from response spectrum analysis with the results from time-history analysis for a conservatively selected sample of insert and withdrawal piping runs. The basis for the licensee's revised load factors was reviewed during an NRC team inspection at the Browns Ferry site from October 16 through October 27, 1989, as documented by IR 50-260/89-44. This review found that the licensee's new design criteria provisions had been adequately justified and were acceptable. TVA provided a summary of these design criteria provisions for the CRD piping and supports in its revised program plan, submitted by letter dated December 11, 1989. Based on a review of the revised design criteria for the CRD reanalysis documented in IR 50-260/89-44, the staff concludes that TVA has adequately resolved the open issue regarding special design criteria provisions for combining multiple pipe loads on the CRD support frames. The staff further concludes that if properly implemented, the program will provide confidence that sufficient margins exist in the CRD insert and withdrawal piping supports to sustain design-basis loads for Unit 2 restart.

2.2.3.3 Small-Bore Piping Program

Section 2.2.3.3 of SSER 1 summarizes the staff's evaluation of TVA's program to address concerns raised regarding the criteria used to design and install pipe supports for seismic Class I (safety-related) small-bore (less than 2½-inch diameter) piping at BFN. In SSER 1, the NRC staff found the licensee's two-phase program, which uses a sample rigorous analysis and generic attribute approach, adequate for the resolution of concerns identified with small-bore piping. However, the staff identified a concern about the sample size being rigorously analyzed by the TVA program. Resolution of the staff's concern about sample size is documented by IR 50-260/89-36. As discussed in this inspection report, the licensee rigorously analyzed additional piping and supports during the generic attribute phase of the program. However, the staff still felt that additional pipe supports should be rigorously analyzed to achieve TVA's originally proposed sample size of 10 percent. To resolve this concern, TVA committed to rigorously analyze an additional 100 pipe supports within the restart scope of the program. TVA confirmed this commitment in a followup response to the inspection report (TVA letter dated November 6, 1989). On the basis of the licensee's commitment to rigorously analyze an additional 100 pipe supports before the restart of BFN Unit 2, the staff concludes that TVA's two-phase program is acceptable. During the NRC inspection of TVA's program implementation (documented by IR 50-260/89-36), two open items were identified. The first open item involved the interface between the rigorously analyzed small-bore piping and equipment. This item also applied to large-bore piping. Closure of this open item for small-bore and large-bore pipe was addressed in IR 50-259, 260, and 296/90-37, issued January 8, 1991. The second open item involved the sample size selected for the rigorous analysis sample discussed previously. The resolution of this item is documented by IR 50-260/89-44.

2.2.3.4 Instrument Tubing Program

Section 2.2.3.4 of SSER 1 summarizes the staff's evaluation of TVA's program to address concerns raised regarding the design and installation of seismic Class I instrument tubing at BFN. In SSER 1, the NRC staff concluded that the licensee had defined an adequate program for resolving the concerns involving the qualification of seismic Class I tubing at BFN Unit 2. Pending resolution of the concerns identified in IR 50-260/89-36, the staff further concluded that the program, if adequately implemented, will provide confidence that sufficient margins exist in tubing within the restart scope of the DBVP to support Unit 2 restart. Two open issues regarding implementation of TVA's instrument tubing program were identified in IR 50-260/89-36. These issues were resolved in a followup inspection and documented in IR 50-260/89-44.

2.2.4 Miscellaneous Issues

2.2.4.1 Mechanical and Electrical Equipment

The issues relating to the seismic qualification of mechanical and electrical equipment will be resolved when the NRC staff implements its resolution of USI A-46 (i.e., after restart).

2.2.4.2 Seismic Class II Features Over Seismic Class I Program

Section III.3.10 of the BFNPP describes the licensee's special program to address a concern identified about the interaction of seismic Class II (non-safety-related) systems with seismic Class I (safety-related) systems. Seismic Class I and II systems are discussed in Appendix C to the Browns Ferry FSAR where it is stated that an item designated Class II shall not degrade the integrity of any item designated Class I. However, the FSAR does not describe specific design criteria applicable to Class II systems.

TVA proposed a two-phase program to address Class II systems at BFN. The first phase, to be completed before the restart of Unit 2, involves the evaluation of potential seismic-induced water spray effects of Class II systems on Class I systems. The second phase of the program involves the evaluation of potential seismic-induced, spatial interaction effects of Class II systems on Class I systems. TVA proposed to address this issue as part of the resolution of USI A-46, "Seismic Qualification of Equipment in Operating Plants."

The staff's evaluation of TVA's program is detailed in Section 2.2.4.2 of SSER 1. In SSER 1, the staff concluded that TVA's proposed program to evaluate the water spray effects of seismic Class II piping systems on seismic Class I piping systems is an adequate interim approach that allows for the restart of

Unit 2. TVA has subsequently notified the staff by letter dated January 3, 1991, that the first phase of its program is complete. However, for long-term operation, the licensee is to comply with the final NRC resolution of generic issues related to seismic interactions, including USIs A-17 and A-46.

2.2.4.3 Torus Modification

All issues relating to this design area were resolved under TVA's Browns Ferry Nuclear Plant Torus Integrity Long-Term Program. The staff issued its safety evaluation of this program in a letter dated August 20, 1980.

2.2.4.4 Torus Attached Piping

Section 2.2.4.4 of SSER 1 summarizes the staff's evaluation of TVA's program to address discrepancies between the design drawings and recent modifications to torus attached piping. Torus attached piping was part of the scope of the NRC's generic issue involving Mark I containment designs. As discussed in SSER 1, the design criteria and the licensee's implementation of the design criteria had been reviewed by the NRC staff and its contractor, Brookhaven National Laboratory. However, during an inspection of TVA's IE Bulletin 79-14/79-02 program (documented by IR 50-260/89-15), the staff found that TVA had made recent revisions to the design criteria applicable to torus attached piping. During a followup inspection (documented by IR 50-260/89-44), the staff found that TVA had committed in Employee Concerns Subcategory Report 21800 to submit one of the design criteria changes to the staff for review. The criteria change allowed the calculated stresses for certain thermal loads to exceed the code-allowable stresses by 5 percent. TVA's response to the inspection report (in a letter dated March 16, 1990) stated that the design criteria would be revised to eliminate this provision and that the piping would be qualified to the code-allowable stress limits. The staff's review of the remaining changes to the design criteria for torus attached piping did not identify any additional changes to the previously accepted allowable stress limits. On the basis of the licensee's commitment to meet the code-allowable stresses that had been previously reviewed and approved, the staff considers that the open issue regarding design criteria has been adequately addressed.

2.3 Heat Code Traceability

Section III.14.5, "Heat Code Traceability," of the BFNPP stated that the issue of heat code traceability had been previously addressed by the Employees Concerns Task Group in its Report No. 40700. The staff reviewed this report as part of its review of the Employee Concerns Special Program for Unit 2 restart. Section 5 of SSER 2 summarizes the staff's findings.

2.4 Platform Thermal Growth

The licensee has reviewed several issues related to thermal growth of structural platforms. The thermal loads on the drywell steel/access platforms are discussed in Section 2.2.2.5 of SSER 1 and SSER 2.

TVA has also evaluated the effects of platform thermal growth outside the drywell. The staff reviewed TVA's evaluations and concluded in IR 50-260/89-42 that the inspection concerns of IR 50-260/89-29 were adequately resolved and that TVA's evaluation results and modifications were reasonable.

3 SPECIAL PROGRAMS

3.1 Fire Protection

The NRC staff evaluation of TVA's fire protection program described by the BFNPP (through Revision 2) is documented in Section 3.1 of NUREG-1232, Volume 3, and SSER 1. As mentioned in SSER 1, the staff conducted two inspections (IR 50-259, 260, 296/89-13, dated August 1, 1989, and IR 50-259, 260, 296/89-28, dated September 15, 1989) of TVA's fire protection program for the express purpose of determining Unit 2 compliance with Appendix R to 10 CFR Part 50. Although two unresolved items (URIs) and numerous inspector followup items (IFIs) (primarily related to the completion of plant modifications) were identified, no serious programmatic deficiencies were noted.

The staff completed its evaluation of Browns Ferry Appendix R issues, including deviations from National Fire Protection Association (NFPA) code requirements, and documented it in a supplement to the previous SER issued December 8, 1988, on Appendix R, "Safe Shutdown System Analysis." This supplement was transmitted to the licensee by letter dated November 3, 1989. Since then, the staff conducted two additional followup inspections that closed out the remaining URIs and IFIs, confirmed that plant modifications were completed, and completed the final inspections for verifying compliance of Unit 2 with Appendix R before restart. These inspections were documented by IRs 50-259, 260, and 296/90-06 and 90-11, dated April 3 and May 11, 1990, respectively.

On the basis of previous staff SERs and inspections, the NRC staff concludes that BFN Unit 2 complies with Appendix R to 10 CFR Part 50. However, the staff must still approve before restart TVA's license amendment application of April 14, 1989 (TS-268), which will incorporate administrative controls for the BFN Appendix R Safe Shutdown Program into the license and Technical Specifications (TSs). This amendment will allow TVA to fully implement its NRC-approved program under the auspices of its license and TSs in a manner consistent with the actions specified in Generic Letter (GL) 86-10. Any subsequent changes to this program could be accomplished within the guidelines of 10 CFR 50.59.

3.2 Environmental Qualification of Electrical Equipment

A detailed evaluation of this program is documented in Section 3.2 of NUREG-1232, Volume 3. In this evaluation, the staff concluded that the Browns Ferry equipment qualification (EQ) program for electrical equipment located in harsh environments complied with the requirements of 10 CFR 50.49. However, full implementation of the EQ program awaited completion of certain activities, such as equipment replacement, modifications, engineering analysis, and documentation. When the EQ program was approximately 75 percent implemented, TVA notified NRC by letter dated June 11, 1990, that "TVA considers BFN ready for the NRC EQ audit." NRC conducted a team inspection of the BFN EQ program during June 26-30, 1990. This inspection was to include closeout of the IFIs and URIs identified in a previous EQ inspection (IR 50-259, 260, and 296/88-11, dated September 1, 1988). Additionally, this inspection also evaluated other EQ issues identified since the previous EQ inspection. The staff concluded from the June 1990 inspection that TVA was implementing an EQ program that would bring BFN Unit 2 into compliance with the requirements of 10 CFR 50.49 once the program is completed (before Unit 2 restart). Results of the EQ team inspection were documented in IR 50-259, 260, and 296/90-22, issued December 14, 1990.

As any licensee must, TVA is required to certify that its 10 CFR 50.49 list is complete and that all electrical equipment and components within the scope of 10 CFR 50.49 are qualified to meet the requirements of 10 CFR 50.49. TVA will issue this certification to NRC before restart of Unit 2. The staff plans to conduct a final followup EQ inspection after certification.

3.3 Piece-Part Qualification Program

Deficiencies in TVA's site-wide practices for the procurement and control of safety-related replacement items were identified in TVA Nuclear Safety Review Staff Reports R-84-17-NPS, R-83-13-NPS, and R-85-07-NPS. NRC IRs 50-327, 328/86-61 and 50-327, 328/88-07 cited similar deficiencies at TVA's Sequoyah facility that were classified as potential enforcement findings concerning failure of the licensee to take corrective action. Section III.12.0 of of the BFNPP describes a program intended to correct deficiencies in component and piece-part qualification and control at the BFN site. TVA is currently preparing and implementing the necessary procedures and guidance for this program at BFN.

The BFN Items Evaluation Group (IEG) was established to involve the nuclear engineering organization (NE) in the procurement process. The IEG's two primary goals are to

- Verify that equipment certified previously as environmentally qualified has not been degraded through the use of spare and replacement parts.
- Establish programs and practices that will ensure that equipment certified previously as seismically and environmentally qualified will not be degraded in the future through the use of spare and replacement items.

The major IEG activities to implement the program (in two distinct phases) are as follows:

(1) Before restart of Unit 2

(a) Review plant maintenance history to identify activities that have replaced safety-related components or items.

(b) Evaluate replacement items that have been installed in 10 CFR 50.49 systems.

(c) Evaluate 10 CFR 50.49 inventoried commercial grade spare parts to assure that their subsequent use will not degrade previously qualified equipment.

(2) After restart of Unit 2

(a) Evaluate safety-related replacement items installed in safety-related applications other than 10 CFR 50.49 systems.

Seismically sensitive components at BFN will be reviewed in accordance with the TVA response to USI A-46 requirements in Generic Letter 87-02.

(b) Evaluate remaining inventoried commercial grade spare parts to assure that their subsequent use will not degrade previously qualified equipment.

(c) Develop pre-engineered specifications detailing technical and quality requirements, source audit and inspection requirements, receipt inspection requirements, part conditioning requirements, and if applicable, post-maintenance testing requirements.

(d) Establish a conditional release program that will require justification and review by senior management for installation of any item that is nonconforming or otherwise not documented as meeting criteria for a specific safety-related application.

In order to better assess the status and depth of the Component and Piece-Part Qualification Program, the staff inspected copies of some of the program guidance and implementation documents supporting Section III.12.0 of Volume 3 of the BFNPP. These documents are briefly described as follows:

(1) B22 '89 0227 754, "Replacement Items Projects," BFN Program Plan, February 1989.

Description - The program plan elaborates on the outline provided in Section III.12.0 of the BFNPP by identifying major tasks for developing 10 CFR 50.49 replacement item evaluation requirements and providing definitions and references.

(2) B01 '89 0620 001 NEP-4.1, "Procurement," Revision 2, June 15, 1989.

Description - This NE procedure establishes the organizations and control for identifying and establishing the quality and technical requirements necessary to support the procurement of permanent plant equipment, materials, and non-personal services. It specifies responsibilities within TVA for procurement and requirements related thereto.

(3) Site Director Standard Practice (SDSP) 16.1, "Evaluation and Dedication of Replacement Parts or Components for 10 CFR 50.49 Application," Revision 6, December 10, 1987.

Description - This procedure explicitly delineates the method for verifying that 10 CFR 50.49 replacement items, obtained through previous procurement practices, have not or will not degrade the equipment qualification status. It verifies that procured items have met all technical, quality, and regulatory requirements. The scope of this procedure is carefully limited, deferring to other procedures as appropriate. For example, current and future procurements of replacement items will be evaluated by the Contractor Engineering Group (CEG) in accordance with SDSP-16.2 and SDSP-16.9.

(4) SDSP 16.16, "Material Issuance and Return," Revision 2, April 25, 1989.

Description - This procedure establishes the method and assigns the responsibilities for the control of material issuance and return activities for site warehousing facilities at BFN. Controls established by this procedure are applicable to materials, components, and spares supplied or procured for use in operations, maintenance, and modification at BFN. References listed in the procedure include 3 documents that provide requirements and 12 that are interface documents.

This program for BFN involves the TVA Division of Nuclear Engineering (NE). NE has coordinated these programs for the various nuclear plants, taking advantage of lessons learned at Sequoyah in developing the program description and supporting procedures and guidance for Browns Ferry.

Conclusions

The staff believes that the program being developed for BFN to assure component and piece-part qualification is likely to correct the deficiencies identified in Section III.12.0 of the BFNPP. The primary reason for this conclusion is that TVA has had recent similar and successful experience at Sequoyah. TVA has learned from this experience and is factoring the lessons learned into the implementing documents for BFN. Staff reviews to date of the program plan described in the BFNPP and available implementing and supporting documents have provided the NRC with confidence in BFN's program to control component and piece-part qualification for restart of Unit 2. The staff also conducted a performance-oriented procurement inspection (see IR 50-259, 260, and 296/90-36), which concluded that TVA was adequately implementing its procurement program at BFN.

3.4 Instrument Sensing Line Issues

The instrument sensing line issues were raised through the Employee Concerns Program. Based on these concerns, three condition adverse to quality reports (CAQRs) were issued to address three basic design requirements for the sensing lines that may have been violated at BFN Unit 2. These basic design requirements are as follows:

(1) Separation of Redundant Components - Criterion 22 of Appendix A to 10 CFR Part 50 requires that the protection system be designed to prevent loss of protection functions as a result of common mode failures of redundant channels. Implementation of this criterion usually includes routing instrument sensing lines with sufficient physical separation to minimize the risk of common mode failure of redundant sensing lines from external hazards.

(2) Provision of Sensing Line Slope - Criterion 20 of Appendix A to 10 CFR Part 50 requires that protection systems be designed to automatically initiate actions to assure that design limits are not exceeded. Further, Supplement 1 to NUREG-0737 requires verification that control rooms contain instruments necessary to support operator actions. Implementation of these requirements involves installation of instrumentation systems whose accuracy can be predicted and accounted for

in instrument setpoints and operator actions. One aspect of this is the installation of sensing lines such that unacceptable measurement errors cannot be induced by gas trapped in liquid lines or liquid trapped in gas lines. Normally, this goal is accomplished by installing lines at a slope so that liquid will drain back to the process fluid for gas pressure measurements and gas will rise back to the process fluid for liquid pressure measurements.

(3) Specification of Material Quality Requirements - Criterion 1 of Appendix A to 10 CFR Part 50 requires that components important to safety be fabricated to quality standards commensurate with the importance of the safety functions to be performed. Implicit in this requirement is the need to specify material quality requirements in design documents and fabrication instructions.

By letter dated August 14, 1989, TVA submitted the corrective action plan to address these concerns related to instrument sensing lines.

The staff has evaluated the TVA submittal on instrument sensing line concerns. The corrective action plan for BFN Unit 2 is similar to the corrective action plan for the instrument sensing lines at the Sequoyah Nuclear Plant (SQN) that has been reviewed and accepted by the staff (NUREG-1232, Volume 2, Part 1, Section 3.4).

As part of this program, TVA reviewed more than 500 instruments. The results of these reviews necessitated walkdown inspections of 146 instruments and their sensing lines. Subsequent engineering evaluations, based on the walkdown inspections, determined that 111 of the 146 instruments were technically acceptable, while 35 needed rework. Engineering change notices (ECNs) were issued to correct problems with the H_2/O_2 analyzers and reactor vessel level instrumentation system lines, and maintenance requests were issued to resolve other minor deficiencies, which were corrected by support adjustments.

The staff conducted an inspection of instrument sensing lines during the week of December 4-8, 1989, as part of an electrical issues inspection. The inspection findings were documented by IR 50-260/89-59, dated February 23, 1990. This inspection confirmed that TVA had taken sufficient measures to verify that instrument sensing line installation at BFN Unit 2 conformed to the design requirements. However, three minor open items were identified during the inspection. These open items were subsequently closed in IR 50-260/90-13, dated August 10, 1990, with only one restart commitment by TVA remaining, which was to evaluate and correct, if necessary, the improper orientation of torus wide-range level instrument lines. A subsequent letter from TVA, dated October 4, 1990, notified the staff that this commitment had been completed (i.e., torus wide-range level instrument sensing lines had been modified and were now within specifications).

The NRC staff concludes that TVA's program has adequately considered the needed accuracy requirements for safety-related instruments, and TVA's technical justifications contain the rationale for allowance of instrument inaccuracies. On the basis of our review of the TVA submittal and inspection, we find the instrument sensing line issues adequately resolved for Browns Ferry Unit 2.

3.5 Welding

See NUREG-1232, Volume 3, SSER 1.

3.6 Intergranular Stress Corrosion Cracking

Some of the welds in certain piping systems of all three units at Browns Ferry have experienced intergranular stress corrosion cracking (IGSCC). In Section 3.6 of NUREG-1232, Volume 3, the staff documented its safety evaluation of TVA's program for mitigating IGSCC at BFN. The staff concluded that the IGSCC program described in Section III.7.0 of the BFNPP was acceptable. The staff also evaluated TVA's program in light of the recommended actions of GL 84-11, "Inspections of BWR Stainless Steel Piping," and as superseded by GL 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping." The most recent and applicable SERs pertaining to these generic letters were issued December 8, 1988, and December 21, 1989. In general, the staff concluded that TVA's program for IGSCC mitigation was acceptable to ensure pipe integrity, with some specific exceptions as noted in the SERs. TVA adequately addressed these staff concerns by letters dated June 30, 1989, and July 13, 1990.

In concert with the aforementioned program evaluations (i.e., the BFNPP and GLs 84-11 and 88-01), the staff conducted a number of inspections (see Appendix F) to examine and verify TVA's implementation of IGSCC mitigation at BFN. Currently, no open inspection items affecting the restart of Unit 2 exist. Furthermore, the following TVA restart commitments for Unit 2, as referred to in NUREG-1232, Volume 3, have been completed as documented by TVA letter dated October 26, 1990:

- Perform all remaining post-induction heating stress improvement (IHSI) inspections.
- Examine all remaining welds that did not receive post-IHSI inspection and carry out sample expansion process in accordance with GL 88-01.
- Replace all cracked shroud head bolts.
- Establish a program for periodic inspection of shroud head bolts.
- Inspect a selected number of control blades.
- Replace wear rings for two of the cross-tie RHR pumps to Unit 2.

Furthermore, the following BFN Unit 2 post-restart commitments were made:

- Hydrogen water chemistry control will be implemented by the next refueling outage.
- Six welds in the core spray system with austenitic stainless steel fittings will undergo IHSI during the next refueling outage.
- The 4-inch and larger stainless steel piping of the reactor water cleanup (RWCU) system located outside containment will be replaced during the next refueling outage (see SER dated December 21, 1989).

3.7 Containment Coatings

TVA's letter of October 4, 1989, provided information on the quantity of existing unqualified coating and the amount of unqualified coating debris that would adversely affect emergency core cooling system (ECCS) pump performance in a post-loss-of-coolant-accident (LOCA) condition. The safety issue that concerns the staff centers on the possibility of collected debris (unqualified coatings and thermal insulation) blocking the residual heat removal (RHR) system suction strainer. This could result in inadequate recirculation cooling capacity and potential core-melt considerations. Unqualified coatings may spall off containment surfaces during a LOCA. The resulting debris may be transported during the ECCS recirculation phase and collect on the suction strainers to the point where the pumps fail on inadequate net positive suction head.

TVA identified coatings inside the Unit 2 containment that did not meet the requirements of Regulatory Guide 1.54, which endorses American National Standards Institute (ANSI) N101.4, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," and ANSI N101.2, "Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities." These coatings were considered to be unqualified and as such were assumed to form solid debris under LOCA conditions. The ANSI standards (ANSI N101.2 and N101.4) meet the criteria of Standard Review Plan 6.1.2, "Protective Coating Systems (Paints) - Organic Materials," for qualification of protective coatings.

Consistent with its commitments in Section III.14.3 of the BFNPP, TVA conducted containment walkdown inspections to establish a baseline for the uncontrolled coating log and to examine the general condition of qualified coatings. Of the 4,480 square feet of coating in the uncontrolled coating log, only 151 square feet of the coating was assumed to contribute to possible suction strainer blockage. This was because approximately 65 percent of the coating surface area in the uncontrolled coating log was less than 3 mils dry film thickness. Coatings of less than 3 mils generally are too thin to sustain the strain of peeling or blistering and are likely to separate or disintegrate into small particles that should not contribute to suction strainer blockage. Also, another 30 percent or so of the uncontrolled coating log surface area should not contribute to suction strainer blockage as the coating was either subsequently qualified by vendors, covered by insulation, or shielded from the LOCA environment. Therefore, the total remaining amount of unqualified coating area assumed to contribute to suction strainer blockage is approximately 151 square feet.

TVA performed a debris transport/settling analysis which indicated that 151 square feet of unqualified coating debris could be transported to the suction strainers without exceeding the 65 percent blockage criteria. Therefore, the ECCS pump performance should not be adversely affected by the debris from the 151 square feet of unqualified coating. The staff has reviewed this analysis and considers it acceptable and conservative as no credit was taken for debris settling in the drywell.

In summary, the amount of unqualified coating within primary containment is less than the amount that could adversely affect ECCS pump performance in a post-LOCA condition and is therefore acceptable.

3.8 Moderate-Energy Line Breaks

TVA reviewed the consequences of postulated moderate-energy line breaks (MELBs) and verified that a MELB does not preclude the operator's ability to shut down the plant because essential equipment either is located above the resulting flood level or is sealed against the effects of MELBs.

After reviewing the licensee's analysis, the staff concluded in Section 3.8 of SSER 1 that the consequences of MELBs will not preclude the operator's ability to shut down the plant, contingent upon the completion of three modifications before restart. TVA determined these modifications were necessary and has confirmed their completion by letter dated October 26, 1990.

3.9 Probabilistic Risk Assessment

The staff reviewed both revised draft versions of the probabilistic risk assessment (PRA), as well as TVA's response to a staff audit finding, and concluded in SSER 1 that the Browns Ferry facility was not an outlier with respect to core-melt frequency when compared to similar plants of the same vintage. The PRA results for Browns Ferry were considered acceptable for the restart of Unit 2.

However, the staff did identify two issues requiring further response from TVA. The first issue involved a potential ECCS single-failure vulnerability and the second involved the adequacy of emergency operating procedures (EOPs) pertaining to the RHR system. Regarding the first issue, TVA confirmed by letter dated May 24, 1990, that the RHR pumps could perform their safety function (i.e., low-pressure coolant injection [LPCI]) following a design-basis accident (DBA) for short-term core cooling, as described in the FSAR (Table 6.5-2), without their pump motor coolers available. Furthermore, TVA updated Table 6.5-2 in Revision 7 of the FSAR to clearly describe the short- and long-term ECCS pump combination requirements. TVA has also committed to revise the BFN PRA to reflect these short- and long-term requirements (this is a post-restart commitment). The second issue was addressed by TVA in its May 1, 1990, letter, which committed to resolve the staff's concerns by revising associated human factors considerations and incorporating the use of the hardened vent in the next PRA update due September 1, 1992, as part of the Individual Plant Examination (IPE) program specified in GL 88-20. The staff concludes that both these issues, as described in SSER 1, are adequately resolved for restart of BFN Unit 2.

3.10 Thinning of Pipe Walls

See NUREG-1232, Volume 3.

3.11 Electrical Issues

3.11.1 Overload Protection of the Motor Control Center Circuits

Overload protection for motor control center (MCC) circuits was evaluated and documented in Section 3.11.1 of Volume 3 of NUREG-1232. The staff concluded that TVA had identified the root cause of the MCC circuit protection problem. The licensee's program for corrective actions, including the actions necessary to prevent recurrence, was determined to be acceptable by the NRC staff. However, the staff also concluded that TVA should accomplish the following actions before Unit 2 restart: (1) resolve the specific problems identified in CAQR BFN 880911; (2) review and correct calculations; and (3) if necessary, replace thermal-overload protection devices for the 480-V ac and 250-V dc MCC circuits. According to TVA letter dated October 26, 1990, item (2) is complete but items (1) and (3) remain open. TVA is to notify the NRC when they are completed.

3.11.2 Overload Protection of Circuits by Fuses That Limit Current

The overload protection of circuits by fuses that limit current was evaluated and documented in Section 3.11.2 of Volume 3 of NUREG-1232. The staff concluded that (1) TVA had identified the root cause for the misapplication of current-limiting fuses and (2) the program provided by TVA to correct this misapplication was acceptable. Implementation, including fuse tabulation on drawings, will be completed before Unit 2 restart. TVA is to notify the NRC when implementation for Unit 2 restart is completed.

3.11.3 Ampacity

In 1986, the Institute of Nuclear Power Operations (INPO) performed an audit on the Bellefonte plant that revealed inadequacies in TVA's electrical design standards DS-E 12.1.1 through DS-E 12.1.4. Because these standards have been used to size all the insulated power cable ampacities (auxiliary and control) throughout TVA's nuclear plants, the potential existed for undersizing of safety-related cables at the Browns Ferry Nuclear Plant. TVA developed a new design standard, DS-E 12.6.3, "Ampacity Tables for Auxiliary and Control Power Cables (0-15,000 volts)," which corrected all inadequacies. This standard was based on various recognized industry standards and test reports on cable ampacity. The new standard also addressed ampacities for cables in conduits, cable trays, and duct banks, as well as derating factors for cable coatings, fire wraps, cable tray covers, and cable tray bottoms, all of which are required by 10 CFR Part 50, Appendix R. TVA established an ampacity program to determine the extent of nonconformance and to implement corrective actions for any nonconformances at BFN.

3.11.3.1 Ampacity Program Plan

By letter dated January 25, 1988, TVA submitted the ampacity evaluation program plan, Revision 0. In this program, TVA planned to establish a remaining life of at least 2 years for all auxiliary and control power safety-related cables, even though cables may have been operating beyond their design rating.

At the Browns Ferry site on April 26, 1988, a meeting was held between TVA and NRC staff members to discuss the program plan. In this meeting, TVA agreed with the staff that any cable that does not meet the plant life requirements will be replaced. The staff expressed concern about operating cables beyond their design rating (see NRC meeting summary dated May 17, 1988). By letter dated July 7, 1988, TVA submitted Revision 1 of the ampacity program plan. In accordance with the revised ampacity program plan, safety-related cables will not be operated at temperatures greater than their qualified maximum temperature rating or their design rating, whichever is smaller. The ampacity program plan for BFN Unit 2 is similar to the previously approved ampacity program plan for Sequoyah Nuclear Plant (SQN), except for two major differences.

The first difference is related to the method of sampling. At Sequoyah, TVA used Military Standard 105D as the basis for obtaining a 95/95 assurance level (i.e., giving 95-percent assurance that at least 95 percent of the population is acceptable). At Browns Ferry, TVA proposed using a sampling plan based on NCIG-02, Revision 2, which was issued by the Electric Power Research Institute (EPRI) as NP-5380, Volume 2. It should be noted that the staff expressed concern about Military Standard 105D during the Sequoyah ampacity review. The staff has reviewed the proposed sampling approach at Browns Ferry for the ampacity program and has found it acceptable. However, during the implementation of the ampacity program, TVA decided to analyze 100 percent of V4/V5 cables and a large number (3,500) of V3 cables (see Section 3.11.3.2 for definition of V3, V4, and V5). Hence, the question of sampling became moot at Browns Ferry.

The second difference is related to the application of load diversity and time diversity in conjunction with hot spot consideration in the ampacity program at Browns Ferry. At Sequoyah, TVA did not take any credit for the load diversity and time diversity. These terms are defined below:

- Load Diversity Analysis - A conservative technique that recognizes that within a tray system a reserve heat capacity exists for cables that are loaded below their rated amperage and apportions this margin to other more heavily loaded cables in the system.

- Time Diversity Analysis - The application of the load diversity analysis for specific operating modes (i.e., normal operation, shutdown, accident condition, single-unit operation with other units shut down, etc.).

- Hot Spot - A hot spot can be produced by the unanticipated bundling together of a few tightly packed, heavily loaded cables in a tray with many other underloaded cables.

The staff reviewed Revision 1 of the ampacity program plan and issued a request for additional information by letter dated August 10, 1988. By letter dated September 30, 1988, TVA provided the requested information. It should be noted that the current ampacity standards do not allow any credit for load or time diversity, although the standard effective at the time of BFN licensing did allow some credit for diversity. Based on a review of TVA's responses, the staff decided to obtain technical assistance from Sandia National Laboratories (SNL) in order to evaluate the ampacity program.

The NRC staff and SNL representatives met with TVA officials at Browns Ferry on February 2, 1989, to discuss the ampacity program. During this meeting, several questions were raised concerning TVA's methodology for applying diversity (see NRC meeting summary dated February 15, 1989). By its letters dated March 17 and April 18, 1989, TVA submitted additional information to resolve the questions raised by the staff and its consultant. The initial review of TVA's submittal identified a number of assumptions used in the TVA program. Some of these assumptions were clearly conservative, some were somewhat unconservative, and others could not be so readily classified. TVA's ampacity program is based on Stolpe's experimental work, which was based on random cable trays. During the meeting on February 2, 1989, TVA also presented experimental data and compared them with the ampacity program's prediction and the results of a finite element computer code (HEATING 6) for cables in a randomly filled cable tray. TVA's position was that the cable trays at Browns Ferry were not randomly filled and that the ampacity program was, therefore, designed to assess worst possible cases.

In consultation with SNL, the staff decided to resolve this issue expeditiously by conducting some additional independent worst case simulation rather than confirming or agreeing with all the assumptions used by TVA in its computer code simulations. Hence, by letter dated March 21, 1989, the staff sent two test cases developed by SNL to TVA to be analyzed by TVA's ampacity computer code. The test cases were specifically devised to challenge the ampacity program and to take advantage of possible program weaknesses. By letter dated April 27, 1989, TVA submitted the results of its analysis. Sandia used the results of the TVA ampacity analysis as input to a finite element computer code (COYOTE), which predicted temperatures as much as 28° above the allowable 90°C predicted by TVA's ampacity analysis. To reconcile the differences between these two analyses, TVA performed a laboratory test using the given test cases. The test results showed that maximum temperatures were below the 90°C used in the TVA ampacity calculations.

A followup meeting was held at BFN on July 10, 1989 (see NRC meeting summary dated August 21, 1989) to discuss the ampacity program. In this meeting, TVA also presented the results of the analysis, using HEATING 6, with results typically 5° or more lower than SNL's, depending on the assumptions used. At this meeting, reasons were discussed for the differences between the experimental results and the computer predictions. The test case was developed to challenge analytical predictions in as simple a manner as possible. In terms of an experimental program, a different physical configuration (many more cables but of smaller sizes and more tightly packed) would be expected to more closely match the finite element predictions.

At the July 10 meeting, TVA was again questioned about the randomness of cable loadings in actual cable trays. Upon clarification of the definition of "random," TVA indicated that the cables were in fact randomly installed in the trays but that the depth of fill in the trays was not uniform. Previously, TVA had interpreted randomness to include uniform depth. With a valid randomness assumption, the worst case analysis is less critical if the probability of existence of actual trays that are "close" to the bounding cases is sufficiently low. Sandia performed a computer simulation of a random tray to assess the probability of an actual random tray being near a worst case condition. The test case given to TVA, with 22 large cables of which 6 were loaded, was used in the simulation. The results of the probability analysis, based on a simulation of 20,000 random trays, indicated that in more than 95 percent of the simulations, fewer than four loaded cables were together; and in more than 99 percent of the simulations, fewer than five loaded cables were together. From this information, it can be concluded that in a real random tray, such as one most likely found at BFN, with many smaller cables, the probability of having loaded cable densities corresponding to the test case would be considerably lower. Hence, it can be concluded with 95/95 assurance that the TVA test of six loaded cables together resulting in temperatures below those allowable demonstrates the adequacy of the TVA load diversity computer code.

The TVA ampacity program at BFN is being carried out in three phases. During Phase I, design standard DS-E 12.6.3 is used to conservatively determine the adequacy of the cables. In Phase IIa, for any cables that do not meet DS-E 12.6.3 requirements, the actual installation and load requirements are determined to allow for a reduction of some conservatism. TVA has performed the plant walkdown inspection to determine the as-built configuration of raceways, such as conduit and tray fill, tray cover and bottom, thickness of flame-retardant coatings, fire wraps, fire stops, and pressure seals. If cables do not meet the acceptance criteria after Phase IIa, then load diversity is applied during Phase IIb and time diversity is applied during Phase III. If any safety-related cable does not pass the acceptance criteria after this three-phase evaluation, it will be replaced with a 90°C-rated cable fully sized to the conservative requirements of DS-E 12.6.3.

However, the staff became aware that TVA was not using a derating factor for tray covers less than 10 feet long. TVA only applied a 25-percent derating for tray covers over 10 feet long. The staff requested TVA to justify this position for all nuclear facilities. TVA responded that this position was based on engineering judgment. The staff then requested TVA to either conduct a test to determine the derating factor or reduce tray cover lengths to 6 feet. In the staff's best judgment, the lack of derating factors will not affect restart of BFN Unit 2 but will only reduce the future life expectancy of the affected cables.

Hence, the staff requests that TVA establish derating factors (including a technical basis) for cable tray covers between 6 and 10 feet long, and take the necessary corrective actions which result, before the end of the first refueling outage following restart of BFN Unit 2.

3.11.3.2 Ampacity Analysis

By letter dated October 6, 1989, TVA submitted the results of its ampacity analysis for BFN Unit 2 cables for the three voltage levels defined below.

- V3 - Auxiliary and control ac and dc power cables operating at a voltage of up to 277 volts and a current of less than 30 amperes

- V4 - Auxiliary ac and dc power cables operating at a voltage up to 600 volts (including cables of 277 volts or less with a rated load current of 30 amperes or greater)

- V5 - Medium-voltage auxiliary power cables with a nominal voltage of 5, 8, or 15 kV

The following describes the results of the ampacity analyses by voltage levels.

- V3 Cables (Control Power and Control Function Cables)

  TVA provided justification and documentation for excluding certain V3 cables that carry low-level and/or intermittent signals for which the ampacity rating of the cable is of no concern. Of the 3,500 cables reviewed for V3-level cables, none of the cables were determined to be control power cables that would have required ampacity evaluation. Hence, no deficiencies were identified for this group of cables.

- V4, V5 Cables (Low-Voltage and Medium-Voltage Cables)

  TVA evaluated 100 percent of the cables in this group. For the 263 safety-related V4/V5 cables routed in dedicated conduits, no failures were identified. For the remaining 941 cables, which are primarily routed on trays and which include 194 safety-related cables, 66 safety-related cables failed to meet the ampacity requirement. In addition, further review of the latest Q-list identified three more safety-related V5 cables requiring ampacity analysis. Of these three cables, two met the ampacity requirement and the third one will be replaced because of cable separation requirements. Hence, no ampacity analysis was performed for this last cable. TVA will replace all the failed cable before startup of Unit 2.

3.11.3.3 Cable Ampacity Program Implementation

During December 4-8, 1989, the staff conducted a team inspection of various BFNPP electrical programs, which included the cable ampacity program (Section III.13.2 of the BFNPP). A primary purpose of this inspection was to verify the adequacy of TVA's implementation of its cable ampacity program by focusing on (1) how the program was carried out; (2) data input to the computer program, including its sources; and (3) results of computer calculations. Only one open item was identified by this inspection (IR 50-260/89-59, dated February 23, 1990), which was subsequently closed in a followup inspection (IR 50-260/90-13, dated August 10, 1990).

3.11.3.4 Conclusions

Based on the staff's safety evaluation (previously transmitted to TVA via letter dated December 19, 1989) and inspections of TVA's ampacity program described above, the staff concludes that there is reasonable assurance that cables at Unit 2 will not be utilized above their rated temperature and will be capable of performing their intended safety functions under normal, abnormal, and accident conditions. However, the staff's concern regarding derating factors for cable tray covers remains unresolved. TVA is requested to provide the NRC with an adequate technical basis for derating factors of cable tray covers between 6 to 10 feet long and to take any necessary corrective actions by the end of the first refueling outage after restart of Unit 2. Furthermore, TVA is requested to notify the staff before restart when all the cables that failed to meet ampacity requirements have been replaced.

3.11.4 Cable Separation

On October 8, 1986, TVA discovered electrical cable separation problems at BFN while implementing a design change to upgrade electrical penetrations in primary containment. TVA documented these discrepancies in Licensee Event Report (LER) No. 88-032, dated October 21, 1988. Subsequently, TVA established a program for electrical cable separation to determine the extent of nonconformances and to take appropriate corrective actions, as necessary. On November 30, 1988, a meeting was held between the NRC staff and TVA representatives to discuss the issue of cable separation. By letter dated December 15, 1988, TVA submitted a request for temporary exemption from General Design Criterion (GDC) 17 to facilitate fuel loading. By letter dated December 30, 1988, the NRC staff granted the temporary exemption from GDC 17 but required compliance with GDC 17 before restart of Unit 2.

By letter dated January 6, 1989, TVA submitted Revision 0 of the cable separation report to NRC. In this report, TVA presented its program to evaluate the problem of cable separation and the corrective actions necessary to resolve the separation discrepancies. The following categories were used to group cable discrepancies:

(1) Inaccuracies of the cable and conduit schedule discovered during the field walkdown inspections for cable ampacity and satisfaction of requirements of Appendix R to 10 CFR Part 50.

(2) Cables with an IE or an IES suffix, or Q-list cables, that were not designated as either divisional or non-divisional and with questionable raceway routing.

(3) Non-divisional cables that may have been routed in both divisional raceways without circuit protection.

TVA's basic approach to resolve its cable separation problems was to identify populations of cables within the aforementioned categories and then to perform one of three procedures: (1) review 100 percent of the cable population, or (2) perform generic analysis to demonstrate the absence of any safety concerns for the cable population, or (3) inspect a random sample of the cable population.

Since evaluations of cable separation relied on the existing design output documents, TVA first elected to confirm the accuracy of these documents. This evaluation was based on a sampling methodology that would obtain a 95-percent assurance that at least 95 percent of the population is acceptable for the design output documents (95/95 assurance level).

On February 1 and 16, March 7 and 14, and May 11, 1989, the NRC staff met with TVA representatives to discuss the sampling methodology. The staff disagreed with TVA about the acceptance criteria used for the sampling methodology. The staff's position was that any violation of the separation criteria observed during a walkdown inspection should be considered a failure, while TVA's position was that unless the violation was safety significant, it would not be considered a failure. By letter dated June 9, 1989, TVA submitted Revision 1 of the cable separation report. In this report, TVA agreed with the staff's position regarding the acceptance criteria for the sampling methodology.

The NRC staff reviewed Revision 1 of the cable separation report and held a meeting on September 5, 1989, with TVA to discuss the staff's concerns. By letter dated October 23, 1989, TVA submitted Revision 2 of the cable separation report. The staff and TVA representatives held a conference call to discuss Revision 2. By letter dated December 14, 1989, TVA submitted Revision 3 of the cable separation report to clarify statements made in Revision 2. The staff concluded that this final revision adequately resolved the issue of the accuracy of the design output documents.

TVA examined the design output documents to review the cable separation problem. TVA then divided the cable population into different groups, based on known discrepancies, and evaluated either the sample cable population or the total cable population. This initial evaluation identified more than 230 discrepancies that required further scrutiny. TVA developed corrective actions for all separation discrepancies. The NRC staff reviewed the sampling criteria for different groups and the corrective action plans for resolving identified discrepancies and found them acceptable. During the week of December 4-8, 1989, the staff also conducted an inspection of cable separation during an electrical issues inspection. The staff's findings from the inspection are documented in IR 50-260/89-59. This inspection did not identify any open item regarding cable separation except that at a future date the staff would perform a signal trace of some cables to verify the accuracy of the design output documents. The staff conducted a followup inspection (IR 50-260/90-13) which examined the test results from signal tracing of 13 additional cables. It was determined that these results did not represent any violations of cable separation or Appendix R requirements.

Conclusions

Based on the staff's evaluation and inspections of TVA's cable separation program, the staff concluded that TVA's program to identify cable separation discrepancies against design requirements and the associated corrective actions to resolve these discrepancies were acceptable. Consequently, the cable separation issue is considered adequately resolved for BFN Unit 2.

3.11.5 Cable Installation

The Employee Concerns Program for the Watts Bar Nuclear Plant (WBN) identified many areas in which inadequate cable installation may have caused damage to electrical cables. Because of the generic nature of these concerns, TVA conducted a review of cable installation practices at SQN and BFN. The NRC staff evaluated TVA's approach to resolve these concerns at SQN and issued its evaluation in Section 3.12 of NUREG-1232, Volume 2, Part 1. TVA provided a description of its program to resolve cable installation issues at BFN in Section III.13.1 of the BFNPP.

By letter dated July 18, 1988, TVA submitted a summary report of its review of cable installation at BFN. The NRC staff met with TVA on July 21, 1988, to discuss the report, and by letter dated September 29, 1988, TVA submitted the results of cable testing of BFN cables. On October 25, 1988, the staff audited backup information to the summary report at the TVA Rockville office. This audit was performed to review the cable installation requirements (880714 S0126), material evaluation and comparison of safety-related cables and conduit materials used at SQN and BFN (880714 S0128), and the cable walkdown inspections (880714 S0129). Following this audit, the staff requested additional information by letter dated November 21, 1988. TVA responded by letter dated December 9, 1988.

To resolve the issue of cable installation at BFN, TVA evaluated the extent to which the cable installation at BFN was enveloped by the SQN cable installation and established a corrective action plan for the areas that were not enveloped by the SQN installation. TVA performed the following activities:

- Compared the cable installation requirements at BFN with those throughout the industry during the period of BFN's construction and also compared those requirements with the SQN requirements.

- Compared the safety-related cable and conduit materials used between SQN and BFN.

- Performed plant walkdown inspections to assess the cable installation practices and the quality of the installed cables.

(1) Cable Installation Requirements

During BFN construction very few, if any, written procedures existed for cable installation and testing in the nuclear industry. However, both BFN and SQN had written procedures to assure that limits of pull-tension were not exceeded, although procedures to address minimum bend radius, vertical support, pullbys, and jamming were not provided until after the majority of cables at both BFN and SQN had been pulled.

Based on the discussion presented in the summary report and the cable installation report, the NRC staff concluded that the majority of the cables at SQN and BFN have been installed in accordance with similar requirements.

(2) Cable Material Comparison

TVA has also compared the cable materials used at BFN with the materials used at SQN. This comparison indicated that most cable contracts were shared by BFN and SQN. In addition, all cables of a particular insulation material were procured to meet the same purchase specification requirement. However, materials available at the time of construction at BFN included a greater quantity of thermoplastic (polyethylene-insulated) cables, which are more susceptible to creep over time at elevated temperatures than other widely used thermoset (rubber) materials. TVA committed to replace all cables that are located in the drywell, the steam tunnel, and the heat exchanger rooms (the three worst case, harsh environment areas) before restart of BFN Unit 2. Replacement became necessary because TVA could not confirm the qualification of these cables for harsh environments.

TVA's review also indicated that BFN does not use silicone rubber-insulated cables in raceways except for pigtail extensions, where the length of the cables is relatively short and the pigtail extensions were qualified by the equipment vendor. The use of these cables was of great concern at SQN.

The NRC staff concludes that the quality of all cable materials used at BFN is at least equivalent to the quality of cable materials used at SQN.

(3) Cable Walkdown Inspections

Plant walkdown inspections to assess the overall installation at BFN indicated that pulling lubricant was evident on condulets and boxes. Also, the average length of the pull and the degree of bends of each pull appeared to be smaller when compared to those at SQN. Additionally, the presence of insulated wires at BFN indicated better installation practices at BFN. During its walkdown inspections, TVA identified deficiencies in cable installation regarding cable bend radii and vertical support requirements. Consequently, TVA has committed to perform a walkdown inspection of all medium-voltage Class 1E cables to assess compliance with requirements for vertical support and bend radii and will also complete any corrective actions before the restart of Unit 2. TVA is to evaluate the vertical support requirement for low-voltage power and control cables and to complete any corrective actions before restart from the next Unit 2 refueling outage. TVA provided the following justification for this post-restart action:

(a) These cables generally operate at or below the temperature rating, below voltage ratings, and with low voltage stress.

(b) Multi-conductor cables are protected by sheaths and binders.

(c) Cables located in the three worst case, harsh environment areas are being replaced before restart.

Based on these justifications, the NRC staff agrees that resolution of vertical support of low-voltage control and power cables can be completed after restart.

In its report of the cable issues walkdown inspection, TVA identified three cuts 1/2- to 3/4-inch long and of indeterminate depth at one pull point in cable 2ES320-I. Since walkdown inspections at SQN did not identify such damage, the staff asked TVA to justify its conclusion that BFN cable installation is enveloped by cable installation practices at SQN. TVA conducted a supplemental inspection and submitted the results by letter dated June 19, 1989. This inspection discovered that the cable insulation cuts were about 10 mils deep. Furthermore, to ascertain the scope of these anomalous indications, TVA had also examined all safety-related cables at Unit 2 that were within the critical jam ratio of $2.8 < D/d < 3.15$ (where "D" is the diameter of the conduit and "d" is the diameter of the cable in the conduit). This examination identified jacket damage to three additional cables. However, no insulation damage was observed. The inspection also revealed that in each of the conduit runs containing damaged cable, the 3-inch condulets were used as pull points. Based on this information, TVA postulated that the cause of the damage was the use of standard condulets as pull points.

To confirm this damage mechanism, TVA conducted a third walkdown inspection and determined that neither jamming nor sidewall pressure would have caused the damage. In fact, an analysis of the data indicated that the damage was caused by pulling large, stiff 600-V conductors, using standard condulets as pull points. On the basis of this walkdown inspection, TVA decided to replace all cables in 3-inch conduits with three 400 MCM cables installed in raceways utilizing 3-inch conduit fittings as pull points.

The NRC staff reviewed TVA's analysis and methodology and conducted an inspection of cable 2ES320-I on February 3, 1989. The staff concluded that TVA's resolution of this cable installation concern was acceptable.

Cable installation requirements, cable material, and cable walkdown inspection information at BFN were compared with those at SQN. However, the staff considers this comparison a subjective method of evaluation and requested TVA to furnish any available test data on the installed cables at BFN. To comply with this request, TVA researched the plant file and transmitted the available test results by letter dated September 29, 1988. This information fell into three basic categories:

(1) DC High-Potential Testing for Installation and Modification of Cables

TVA had previously performed post-installation high-potential testing on medium-voltage cables at 25 kV dc for 15 minutes. Proof tests were also performed at about 18 kV dc for 5 minutes on cables after disconnection/reconnection of splices or terminations. The acceptance criteria required that the leakage current decrease, or at least not increase, over time.

TVA files containing 557 test records on 488 cables indicated that there were no cable insulation failures.

(2) DC High-Potential Testing for Maintenance

TVA had previously performed dc high-potential testing to assess the condition of 4-kV motor windings. These tests were performed in 1-kV increments, with each lasting 3 minutes, up to 8 kV dc. The TVA files contained 577 records on 188 individual cables. The acceptance criteria were similar to the criteria used for category (1) testing, and review of the test records indicated that there were no cable insulation failures.

(3) Environmental Qualification Testing

TVA had previously subjected cable samples from the plant to EQ testing. The cables were subjected to a 2.2-kV ac high potential test after exposure to a LOCA environment. Of the 46 cables tested for EQ, 11 were at least partially routed in conduit. All these cables passed the EQ test.

Each of these three tests was performed on many of the cables routed in conduits, and together these tests covered many of the issues related to cable installation. Although the data collected from these tests do not address all the cable installation issues, sufficient information exists to support an argument that failures resulting from cable installation practices would be random.

TVA subsequently confirmed that the calculations used at SQN to identify the worst case conduit runs for testing purposes contained significant errors. However, TVA satisfactorily demonstrated to the staff that for BFN the worst case group of conduit runs with the potential for damage from cable jamming are bounded by those tested at SQN. Therefore, any additional testing that may be required to reconcile SQN cable installation should not affect the conclusions reached for BFN. In fact, the only benefit from SQN testing that TVA uses for BFN is resolution of the cable jamming issue.

<u>Watts Bar Cable Damage Issue</u>

In June 1989, TVA discovered cable damage while removing a conduit at the WBN site. Further analysis and testing at the University of Connecticut determined cable pullbys to be the root cause of the cable damage. The NRC staff asked TVA to justify BFN cable installation in light of this new discovery. The staff also met with TVA on December 18, 1989, and January 18, 1990, to discuss TVA's proposed approach for resolving this cable installation issue.

By letter dated February 5, 1990, TVA committed to a test program for Unit 2. On February 13, 1990, the staff met with TVA to discuss this test program. As part of its program, TVA committed to select the 10 "worst case" conduit segments (i.e., those that represented the most difficult pullby conditions) and to conduct high-potential tests of each one to verify overall installation integrity.

The staff agreed with the criteria used for selecting the worst case conduits and accepted TVA's program for testing these 10 conduits as a way to resolve the cable pullby issue at BFN even though the staff had previously required SQN to test 15 conduits for cable pullby. The staff accepted a smaller test sample because each of the 10 conduits would be wet tested, whereas at SQN only 3 of the 15 conduits were wet tested. If for some reason a conduit at BFN could not be wet tested, NRC required a substitute for that conduit or an additional conduit to be wet tested. Hence, based on the fact that previous walkdown inspections did not identify any pullby damage and all conduits were to be wet tested (unless approved otherwise by the staff), the staff concluded that the TVA test program for BFN was acceptable.

The NRC staff and its consultant, Sandia National Laboratories, conducted an inspection during the week of April 23-27, 1990, to evaluate TVA's analysis and methodology, to examine TVA's test results, and to perform independent plant walkdown inspections of electrical cables to search for any and all potential installation problems. The inspection findings were documented in IR 50-259, 260, and 296/90-13. The staff concluded in this inspection report that TVA's program to resolve cable installation problems was being implemented properly. Furthermore, the successful completion of all high-potential testing should demonstrate the integrity of affected cables. The consultant's detailed report regarding resolution of BFN cable installation issues in general, and cable pullby in particular, is provided as Appendix G to this SSER.

Since the staff's inspection, TVA issued a series of reports dated July 10, September 19, and October 4, 1990, regarding the progress, methods, results (i.e., tests and walkdown inspections), and final completion of its program to resolve cable installation issues at BFN. In these reports, TVA resolved all the restart concerns regarding vertical support and bend radius of medium-voltage cables. However, TVA determined that five medium-voltage cables classified as Group 1 for bend radius would be replaced during the next scheduled Unit 2 refueling outage because of the severity of the bend radius conditions and the age of the cables. Furthermore, Group 2 cables will be tested and trended for at least the next three refueling outages after Unit 2 restart. Resolution of vertical support for low-voltage cables is scheduled for completion by Cycle 7 startup of Unit 2. The staff has reviewed these reports and except for the issue regarding Brand Rex cable, all other issues are considered resolved. By letter dated January 23, 1991, TVA provided the staff with its determination and rationale that Brand Rex cables at BFN Unit 2 were capable of functioning as intended. The staff reviewed TVA's letter and found the licensee's justification acceptable regarding operability of Brand Rex cables for one more fuel cycle.

Conclusions

The NRC staff concluded that TVA has adequately resolved the issues regarding cable installation practices at BFN Unit 2, except for completion of the remaining restart commitments. TVA is to notify the staff when they have completed the remaining restart commitments (see items 3 and 5 below).

The staff's conclusion that cable installation issues at BFN are sufficiently resolved to ensure the performance capability of safety-related cables for restart of Unit 2 was based on the following premises:

(1) Most of the BFN and SQN cables were installed under similar cable installation requirements and were of similar cable material.

(2) Cable walkdown inspections discovered no significant damage except for the damage caused by pulling large 600-V cables through a standard conduit fitting.

(3) TVA identified the root cause of cable damage to be the use of condulets as pull points for large, stiff 600-V cables. TVA will replace those cables susceptible to such damage before Unit 2 restart.

(4) No silicone rubber-insulated cables were used except for pigtail extensions.

(5) Cables from three of the harshest environmental areas of the plant will be replaced before Unit 2 restart.

(6) Many cables will be replaced in accordance with the conclusions reached in the cable ampacity and the EQ programs.

(7) Cable test data indicated no cable insulation failures.

(8) TVA fully implemented an acceptable test program to resolve the WBN cable damage (i.e., pullby) issue.

(9) NRC inspections conducted at BFN Unit 2 did not leave any open items and confirmed the validity of TVA's analysis and test results.

(10) Corrective actions to resolve the bend radius and vertical drop concerns for medium-voltage cables will be completed before Unit 2 restart from the next refueling outage (i.e., the five medium-voltage cables classified as Group 1 will be replaced).

3.11.6 Diesel Generators

Section III.4.1 of the BFNPP addressed deficiencies associated with electrical calculations, including emergency diesel generator (EDG) performance. The EDGs at Browns Ferry are designed and tested by TVA for use in the onsite Class 1E electrical auxiliary power system (APS). Each EDG was designed to

(1) Start and reach rated voltage and frequency in 10 seconds.

(2) In 10 seconds, connect to the APS to start and accelerate 480-V loads and the designed sequence of large 4160-V motors.

(3) Sustain the loss of all or part of such loads and maintain voltage and frequency within acceptable limits.

(4) Supply power continuously to the equipment needed to maintain the plant in a safe condition for a complete loss-of-offsite-power (LOOP) event.

The EDGs are intended to provide electrical power to the APS following a LOOP event or, worse yet, a postulated design-basis accident (DBA) (i.e., a LOCA) concurrent with a LOOP.

Upon a LOOP, all the loads required for either a safe shutdown or for reducing the LOCA effects are isolated (load shed) from the Class 1E shutdown boards. These loads automatically sequence back onto the shutdown boards after the EDG attains rated voltage and frequency. The 4160/480-V shutdown transformer loads do not load shed and are the initial load supplied by the EDG. Additional loads automatically sequence on at time intervals of 1, 7, 14, and 40 seconds.

There are eight EDGs at Browns Ferry. Four EDGs (A, B, C, and D) supply power to, and are shared by, Units 1 and 2. Four additional EDGs (3EA, 3EB, 3EC, and 3ED) supply power principally to Unit 3. In addition to electrical systems, all three units share some mechanical systems. The present Unit 2 TSs require that EDGs A, B, C, and D be operable before startup. There are electrical ties between EDGs: A and 3EA, B and 3EB, C and 3EC, and D and 3ED. Unit 2 TSs will require revision before restart to include operability requirements for Unit 3 EDGs because the following mechanical systems required to be operable for Unit 2 are powered from Unit 3 EDGs: SGTS train C is powered from EDG 3ED, and control room emergency ventilation system (CREVS) train B is powered from EDG 3EC. TVA submitted a TS amendment application dated July 13, 1990, to include Unit 2 limiting conditions for operation (LCO) requirements for Unit 3 EDGs. The staff is still evaluating TVA's application, which must be processed before restart of Unit 2.

TVA tested the EDGs as part of its restart test program, which included EDG response to a Unit 2 LOOP/LOCA loads application. Voltage and frequency responses were analyzed for acceptability on the basis of transient and steady-state voltage and frequency not exceeding the electrical equipment design.

By letter dated January 20, 1989, TVA submitted the results of its EDG load analysis and tests to NRC for review. The staff also received the "Diesel Load Study DNE Calculation ED-Q2000-87071," Revision 2, for review.

3.11.6.1 Emergency Diesel Generator Ratings

Engine thermal stress is not expected to decrease the EDG's lifetime if the APS transient and steady-state electrical loads do not exceed the EDG ratings. The four limiting load ratings that affect the EDG performance rating are associated with the diesel engine rather than with the generator. As indicated below, two of the ratings are transient and two are steady state:

(1) Transient

Zero to 3 minutes	2815 kW
Over 3 minutes	3025 kW

(2) Steady State

0 to 2 hours	2800 kW
Over 2 hours	2550 kW

Transient loads are the combined running and starting loads that are connected to the EDG at any time during the loading sequence. The transient limitation for the first 3 minutes is imposed because the engine's turbocharger is not effective during this time period. The more-than-3-minute transient load of 3025 kW can be maintained for 30 minutes but would require special maintenance after shutdown.

The EDG ratings listed above include derating in agreement with the vendor's recommendation. This derating is included because the calculated BFN site-specific temperature of 97°F exceeds the EDG vendor design temperature of 90°F. Also, the engine jacket water temperature exceeds the engine design temperature of 190°F. Therefore, the EDG's derating is 1.2 percent for the first 3 minutes of operation and 2 percent for all other operating conditions. The staff finds that the ratings as derated are applicable to the BFN EDGs.

3.11.6.2 Emergency Diesel Generator Load Analysis

The staff's review of TVA's load analysis indicates that all transient and steady-state loads are within the EDG ratings, with the following two exceptions:

(1) For EDG A, the 3197-kW load at 40 seconds exceeded the 2815-kW transient rating. This load dropped back to within the rating 20 seconds later. The staff finds this condition acceptable because

- The time duration of this load was short.

- The residual heat removal service water (RHRSW) pump motor, which is the load applied at 40 seconds, accelerated in 0.939 second, and this time was less than the acceleration time for RHRSW pump motors on the other EDGs.

(2) For EDG A, the 2767-kW load at 2 hours exceeded the greater-than-2-hour steady-state rating of 2550 kW. The staff finds this condition unacceptable, as discussed below.

TVA proposed to take no operator action to shed loads on EDG A after 2 hours for a LOOP/LOCA (2767-kW) load. TVA took this position because the vendor has guaranteed that the engine can supply up to a 3025-kW load for 1/2 hour or a 2900-kW load for 200 hours.

Currently, BFN TS surveillance requirement 4.9.A states: "Each diesel generator shall be manually started and loaded to demonstrate operational readiness.... The test shall continue for at least a one-hour period at 75 percent of rated load or greater...." Therefore, each EDG is tested at 1-month intervals at a minimum load of 1913 kW. There is no existing requirement to test at 18 months (refueling) to the continuous rating of 2550 kW for 22 hours and 2800 kW for 2 hours. Since TVA did not test to the 2900-kW rating, TVA should not take credit for this rating to preclude manual load shed. TVA should either revise its procedures (e.g., abnormal operating procedures and/or emergency operating procedures [EOPs]) to direct the operator to load shed or (in accordance with TS) to routinely test EDG A with a load greater than the LOOP/LOCA load.

The staff concludes from the review of the load study that EDGs have adequate capacity to perform their safety function, with the exception of EDG A loads, which exceed the EDG rating after 2 hours. However, TVA subsequently submitted a TS amendment application dated January 31, 1990, that would require testing the EDGs every 18 months for 24 hours at 100 percent or better of their continuous load rating. The staff is currently evaluating TVA's application.

3.11.6.3 Emergency Diesel Generator Voltage Analysis

EDGs must provide sufficient voltage during load application to ensure that

- Motors develop adequate torque and acceleration.
- Contactors of the 480-V ac motor control centers (MCCs) close and do not reopen. If they do reopen, they must reclose with no effect on the contactors or the motors.
- Contactor control circuit fuses do not open.

TVA performed a voltage analysis to determine the kind of voltage transients experienced during the restart test program's (RTP's) load-acceptance testing. The EDG's terminal voltage, load (kW), line current, and frequency were recorded during the RTP load acceptance testing. The analysis used a composite voltage profile consisting of the worst case transients of the four EDGs for each load sequence step. This approach ensured that the analyzed voltage profile would bound the actual voltage profile experienced by any of the four EDGs during a DBE.

Worst case voltage drop occurred on EDG C at time 0.2 second when the residual heat removal (RHR) pump motor (2000 hp) was started. The voltage dropped to 47.2 percent, then recovered to 90 percent in 3.5 seconds. TVA contacted the RHR pump motor manufacturer concerning the effect of this voltage condition upon the motor. The manufacturer advised TVA that the motor would have sufficient starting torque with the voltage as low as 40.5 percent, and that safe stall time, at locked rotor current, was 14 seconds. The restart special test (ST 88-26) for EDG C indicated that bus voltage was at 80 percent of normal voltage at 2 seconds after the pump started. The RHR pump motor acceleration time was 4.2 seconds. At 4.2 seconds, the voltage was above 100 percent. The staff's review of the 4160-V motor load application on the EDGs determined that these motors developed adequate torque and acceleration.

TVA also analyzed the effects of low voltage on the EDG's 4160-V system as transmitted down to the electrical equipment associated with the 480-V system and concluded that there was no adverse effect upon safety-related motors. The starter contactors that are energized will open the power circuit, and when voltage increases to 80 percent at the contactor coil, the contactor will then close the power circuit. Contactor control fuses will not open, even with an increase in control current, because they are designed with sufficient time-delay characteristics. This increased current results from reduced impedance associated with an open contactor coil and low frequency. The staff considers this low-voltage condition on the 480-V system to be acceptable.

A maximum voltage of 128 percent occurred on EDG D at 3.5 seconds after the RHR pump start. This voltage is above the 110-percent steady-state design for 1-1/4 seconds. TVA determined that the high-voltage transient had no effect on the RHR pump motor supplied by the 4160-V system or on any motor, starter, or control fuses on the 480-V system. The staff finds that the overvoltage condition of the 4160-V system and the 480-V system is acceptable.

The voltage transients, high and low, that occur during the sequenced load application have been verified by test. The staff concludes from the review of the voltage tests and analyses that the electrical equipment will perform its safety function.

3.11.6.4 Emergency Diesel Generator Governor and Frequency Analysis

The EDG governor controls engine speed, generator frequency, or load by adjusting fuel to the engine. During initial testing (ST 88-06 series), TVA noted that for heavy load applications to the generator, the frequency (speed) generally decreased with no increase in the fuel rack position. This finding indicated that no corrective fuel adjustment occurred for a frequency deviation from a load demand setpoint. Further investigation revealed that a low voltage input to the governor was affecting speed control. This situation resulted in improper fuel correction and inconsistent frequency deviation with extended recovery time during the transient condition. TVA, in conjunction with the manufacturer of the governor, conducted tests at the manufacturer's facility. As a result of these tests, three electrical governor control panels were modified and the following recommendations from the manufacturer were implemented:

(1) The null voltage value was set to produce an engine fuel correction upon heavy generator load application, thereby reducing the frequency dip.

(2) The mechanical governor full-speed setpoint was reduced and mechanical droop was incorporated to minimize speed overshoot and to improve transient response during EDG startup.

(3) Additional tests and calibrations were performed at the site to improve the governor response.

Results of special tests (ST 88-21 through 88-24 and ST 88-27 through 88-30) indicated that the frequency of "hot" engine response for each EDG had improved significantly. EDG frequency overshoot and dip were both limited, and frequency response curves compared well between individual EDGs. The staff reviewed the "before" and "after" frequency curves and agrees with TVA that the governor response had improved. The staff's review of the EDG "Load Acceptance Test Data Special Test ST 88-32 (EDG A), ST 88-33 (EDG B), ST 88-26 (EDG C), and ST 88-34 (EDG D)" indicated that the EDG B frequency drop represented the worst case. The frequency had dropped to 58.9 Hz (98.1 percent of nominal) at 3.9 seconds after the RHR pump started. The RHR pump accelerated from zero to full speed in 3.86 seconds. By this time, the frequency had reached 100 percent. The next load application did not occur until 2.14 seconds later. The staff concluded from an evaluation of the governor and frequency analysis that the

EDGs and connected electrical equipment would be capable of performing their intended safety functions.

3.11.6.5 Conclusions

The staff concludes that the Browns Ferry EDG loads are within the EDG ratings, with one exception. This exception is EDG A after 2 hours for a LOOP/LOCA condition. To resolve this exception, TVA submitted a TS amendment application for staff approval that would require routine testing of EDGs for 24 hours at the continuous load rating. This amendment will be processed by the staff before Unit 2 restart.

The staff is also evaluating a TS amendment application submitted by TVA in response to staff concerns that would incorporate Unit 2 LCO requirements for Unit 3 EDGs, which are required to support Unit 2 operation. This TS amendment will be processed by the staff before Unit 2 restart.

Furthermore, the staff concludes that the voltage and frequency responses of the BFN EDGs demonstrated the capability of the EDGs to adequately supply safety-related electrical loads. This conclusion was previously transmitted to TVA in a staff SER dated December 21, 1989.

3.12 Flexible Conduit

Original construction specifications at BFN did not adequately address the requirements for minimum and maximum flexible conduit lengths to allow for thermal and seismic movement. As such, some flexible conduits containing Class 1E cables were not installed at lengths necessary to ensure they would not be damaged as a result of seismic and thermal movements.

In Section III.13.3 of the BFNPP, TVA summarily described its program plan to resolve the flexible conduit issue. A subsequent submittal dated August 18, 1989, provided the staff with a more detailed description of the program.

TVA stated that BFN was initially constructed using General Construction Specification G-3 entitled "Installing Electrical Conduit Systems and Fabricated Conduit Boxes." This specification required that flexible conduit be provided for electrical connections to equipment (such as motors, valves, lighting fixtures) but contained no specific requirement for minimum lengths for seismic and thermal movements.

TVA issued General Construction Specification G-40 (R3) entitled "Installing Electrical Conduit Systems and Conduit Boxes" in October 1980. This specification corrected the shortcoming in General Construction Specification G-3. However, General Construction Specification G-40 was not applicable to Browns Ferry until Revision 9 was issued on January 15, 1986.

In January 1986, TVA discovered flexible conduit at WBN that was not installed in accordance with the requirements of General Construction Specification G-40. Further evaluations revealed that thermal movements for pipe-mounted devices and seismic movement for certain floor-mounted equipment were not based on worst case conditions. In May 1986, TVA issued a plan of action to resolve this problem for all nuclear sites. TVA issued Specification Revision Notice 11 (SRN G-40-11) to General Construction Specification G-40 defining the minimum conduit length for accommodating thermal and seismic movements.

To resolve this issue, TVA plans to inspect all Unit 2 flexible conduit attached to electrical equipment covered by 10 CFR 50.49 (i.e., equipment qualification) before restart. These inspections would verify that the lengths of flexible conduit are adequate to accommodate thermal and seismic movement. Conduits not meeting the acceptance criteria of General Construction Specification G-40 will be documented and reworked to meet the acceptance criteria or technically justified as acceptable as is.

TVA's proposed plan is for 100 percent inspection of the flexible conduit attached to qualified electrical equipment. Flexible conduit not attached to qualified electrical equipment (i.e., important to safety but located in a mild environment) is to be evaluated as part of the BFN USI A-46 program. At present, for operating plants other than Browns Ferry, the generic implementation procedure (GIP) used in the A-46 program does not address flexible conduit. In this regard, the flexible conduit program used at Browns Ferry has not been approved generically by the NRC staff. However, the staff views the BFN flexible conduit program as an interim measure that could enhance plant safety and, as such, as acceptable for Unit 2 restart. For long-term considerations, TVA should fully comply with the final criteria applicable to flexible conduit associated with the NRC's resolution of USI A-46.

The staff concludes that the flexible conduit program at BFN provides assurance that flexible conduits are adequately installed to accommodate seismic and thermal movements of the attached equipment, devices, and pipes. TVA is requested to notify the staff when this program is completed for Unit 2 restart.

3.13 Cable Splices

In 1986, the NRC issued Information Notice (IN) 86-53 alerting licensees to a potential safety problem involving improper installation of heat-shrinkable tubing over electrical splices and terminations. In addition to this information notice, an employee concern was brought up at BFN regarding problems with existing site procedures for installing electrical splices. Based on these concerns, TVA initiated a comprehensive program at BFN to ensure the adequacy of all Class 1E electrical cable splices and terminations in harsh environments (i.e., EQ splices required to conform to the requirements of 10 CFR 50.49).

TVA's comprehensive splice program included the identification and inspection of all splices and terminations (more than 1,000 splices) subject to 10 CFR 50.49. In addition, General Construction Specification G-38 and standard drawings SD-E12.5.3 through SD-E12.5.9 were revised to address splice problems at BFN. As part of the splice program, the Raychem splice installer training classes were improved to make them consistent with Raychem installation instructions and internal TVA procedures.

The staff reviewed the cable splice program as described in Section III.13.5 of the BFNPP (Revision 2). Furthermore, the staff inspected implementation of the program as part of the EQ team inspection conducted June 25-29, 1990, at BFN. During this inspection, the staff reviewed procedures, instructions, and other splice-related documentation to ensure that the documentation was consistent with Raychem installation instructions. Sample splices in the field were visually examined to check for proper installation. Details of the staff's inspection and findings regarding TVA's implementation of the BFN splice program was issued December 14, 1990 (IR 50-259, 260, and 296/90-22).

Based on a review of Section III.13.5 of the BFNPP and inspection activities conducted during the EQ team inspection, the staff concludes that TVA's electrical cable splice program is acceptable and that when the program is completed, it will provide adequate assurance that qualified electrical cable splices within the plant are installed properly. TVA is requested to notify the staff when the splice program is completed for Unit 2 restart.

3.14 Microbiologically Induced Corrosion

The staff concluded in SSER 1 that TVA's inspection and monitoring program for microbiologically induced corrosion (MIC) of the stainless steel portions of the EECW piping system and the HPFP/RSW and RHRSW carbon steel piping systems, if properly implemented, will provide reasonable assurance that these systems will not lose their capability to perform their safety functions because of MIC damage. But, if leakage should occur during operation in ASME Code classed piping systems, the requirements of the ASME Code, Section XI, shall apply and a request for relief is required for the interim period until a repair in accordance with ASME Code Section XI is made or an alternative approach is approved by the NRC staff.

In SSER 1, the staff decided that the EECW piping welds previously inspected by TVA and an additional sample of Unit 2 welds in the baseline radiographic test (RT) inspection would be RT-inspected again before restart of Unit 2. Furthermore, these welds would be inspected during each following Unit 2 outage to monitor for progressive MIC damage. TVA notified the staff by letter dated October 26, 1990, that the aforementioned inspections have been completed.

3.15 Q-List Program

NRC regulations and requirements specify that all safety-related structures, systems, and components be identified. TVA believes that the Q-list performs this function at BFN.

The NRC staff reviewed TVA's Q-List Program as part of the NRC vertical slice team inspection of the core spray system. This inspection was documented in IR 50-259, 260, and 296/89-16, dated March 9, 1990. The Q-List Program at BFN is described in Section III.14.1 of the BFNPP. Subheadings of Section III.14.1 are as follows:

- 14.1.1 Q-List Format and Control
- 14.1.2 Q-List Development
- 14.1.3 Q-List Applications

The Q-List Program and its applications were reviewed and inspected by the staff as detailed in IR 50-259, 260, and 296/89-16.

Q-list format and control and Q-list development were controlled by a nuclear engineering procedure for the BFN project (BFEP-PI-87-52, "Development and Control of the Browns Ferry Unit 2, Phase 1, Q-List"). The staff reviewed this procedure, which described four basic performance elements involved in the development of the Q-list: (1) identify safety-related functions, (2) determine the safety-related systems relied upon to provide the safety function, (3) identify the safety-related components and structures of the systems, and (4) review the licensing documentation to determine other commitments and requirements affecting the safety classification of plant equipment. For each element, the procedure provided detailed steps regarding the source documents to use. An individual Q-list equipment data package was made for each safety-related, limited quality assurance (QA), or nonsafety-related system that has items included on the Q-list.

The staff reviewed TVA's closure package for this BFNPP program. TVA's QA organization at BFN had previously conducted an implementation audit of the Q-List Program in which it concurred with the project procedure (mentioned above) for controlling development, issuance, and updating of the Q-list. Training had also been conducted for all site personnel involved in using the Q-list.

Based on TVA's documented closure of this item and independent reviews and inspections conducted by NRC, the staff concludes that TVA has implemented its BFNPP commitments and that no outstanding issues remain to be resolved regarding the Q-list before Unit 2 restart.

4 READINESS FOR OPERATION

4.1 Operational Readiness Review Program

TVA's operational readiness program represents a comprehensive effort to assess the material condition and personnel readiness at Browns Ferry needed to support safe plant restart and operation following the current extended outage. Site and support organizations were changed, responsibilities were realigned, and new programs to correct past problems were, and continue to be, implemented.

TVA responded to the NRC staff's concerns (i.e., 10 CFR 50.54(f) letter) regarding past BFN performance with a comprehensive effort to improve the quality of plant operations. Sections V.1 through V.8 of the BFNPP represent TVA's assessment of the operational readiness of BFN Unit 2 and describe the program plans necessary to resume safe plant operation.

The staff's evaluation of Section V, "Operational Readiness," of the BFNPP (Revision 2), as clarified by a letter from TVA, dated December 23, 1988, was documented in Section 4.1 of SSER 1, in which the staff concluded that TVA's program was acceptable for Unit 2 restart. As designed, TVA's operational readiness program should provide the BFN site director with confirmation that all the activities, corrective action plans, and commitments required for Unit 2 restart have been completed satisfactorily.

TVA's independent Operational Readiness Review (ORR) activities are continuing. Currently, the most significant elements outstanding are completion of the Phase II closeout and the conduct of Phase III (scheduled for January 1991). Furthermore, the corporate-level review of BFN Unit 2 readiness conducted by the Senior Management Assessment of Readiness Team (SMART) is also under way. The ORR and SMART activities must be completed before the Senior Vice President, Nuclear Power, can recommend to the Commission that Unit 2 is ready for restart.

The NRC staff will continue to evaluate and examine TVA's implementation of the operational readiness program during future NRC inspections. In particular, the staff plans to conduct an Operational Readiness Assessment Team (ORAT) inspection to verify the satisfactory implementation of TVA's ORR, as well as other BFNPP programs, just before the scheduled restart of Unit 2.

4.2 Management

4.2.1 Site Organization and Management

Section II.1.0, "Strengthening BFN Management and Organization," and Section II.2.0, "Management Control and Involvement," of the BFNPP documented TVA's assessment of management and organizational problems at BFN and proposed a wide spectrum of corrective action plans to improve plant performance and address NRC concerns. The staff evaluated specific elements of these BFNPP programs (e.g., corporate support, site organization, management controls, site scheduling, work control) and examined their implementation at the site. The primary purpose of the staff's efforts was to determine whether the commitments made by TVA in the

BFNPP were implemented and, more importantly, whether the resulting site organization and its management control systems could support restart and safe operation of Unit 2. By letter dated July 31, 1990, the staff sent TVA a SER that detailed the staff's findings and concluded that (1) the actions taken by TVA were consistent with commitments made by TVA in the BFNPP and (2) the resultant BFN organization and management control systems could support restart and safe operation of Unit 2. The staff intends to re-examine TVA's site management and organization at BFN during the ORAT inspection just before restart of Unit 2.

4.2.2 Independent Safety Engineering Group

See NUREG-1232, Volume 1, SSER 1.

4.3 Quality Assurance

In Sections 4.3.1 and 4.3.2 of Volume 3 of NUREG-1232, the staff concluded that TVA's QA and CAQR programs (described in Sections II.2.5 and II.2.6 of the BFNPP) were acceptable. In June and July 1990, the staff conducted a special team inspection to verify implementation of these programs, including the newly revised Nuclear Quality Assurance Plan (NQAP). The results of this inspection were documented in IR 50-259, 260, and 296/90-20, dated August 13, 1990. A followup inspection on the corrective action process at BFN was subsequently conducted in November 1990 (see IR 50-259, 260, and 296/90-36). In summary, the staff determined that the CAQR program at BFN was being implemented effectively. Furthermore, the staff determined that TVA successfully planned and monitored the transition from the old Nuclear Quality Assurance Manual (NQAM) to the new NQAP. TVA's long-term performance under the NQAP will continue to be examined by the NRC as part of the routine inspection process. Although TVA at large is instituting a new CAQR program, the corrective action program at BFN will remain unchanged until after Unit 2 restart.

4.4 Plant Surveillance Program

In Section 4.4 of Volume 3 of NUREG-1232, the staff concluded that TVA's upgraded surveillance program (described in Section II.5 of the BFNPP) was acceptable. However, the staff identified the following issues related to program implementation that required TVA's attention: (1) the system engineer concept in relation to the plant surveillance program, (2) surveillance instruction validations, (3) surveillance instruction verifications, (4) improved management practices to foster procedural compliance among personnel, and (5) commitment tracking. Since the issuance of SSER 1, TVA has completed its corrective actions for each of the aforementioned issues, except item (4), as detailed in the TVA letter dated October 26, 1990.

The staff is planning to perform a special inspection of the surveillance program before Unit 2 restart in addition to the ORAT inspection. Although this special inspection will be oriented towards closure of TVA's corrective actions taken in response to the NRC's escalated enforcement (see IR 50-260/89-43), it will also examine TVA's resolution of all the open issues described above (except issue 5, which will be inspected independently). Any safety-significant concerns that remain after this inspection will have to be resolved before Unit 2 restart.

4.5 Maintenance Improvement Program

From its evaluation of TVA's upgraded maintenance improvement program, as described in Section II.4 of the BFNPP and in a letter dated March 15, 1989, the staff drew the following conclusions in Section 4.5 of SSER 1:

(1) The maintenance improvement program, as integrated into Plant Manager Instruction 6.2, "Conduct of Maintenance," will be responsive to identified needs for improvements and the intent of the proposed revised Commission policy statement on maintenance of nuclear power plants.

(2) Appropriate programs are in place that should ensure success if properly implemented.

(3) Information should be available for the NRC performance-based maintenance inspection to allow a determination of the initial implementation of the program. Accumulation of operating history will be required to document the achievements of the program.

The NRC performance-based maintenance team inspection (MTI) was conducted at BFN during January 1990, as documented by IR 50-259, 260, and 296/89-56, dated March 26, 1990. The staff's findings demonstrated that TVA's implementation of its maintenance program was satisfactory. However, since BFN has not operated for a number of years, the staff could not directly assess the capability of the maintenance program to support operations. Consequently, the staff plans to revisit this aspect of maintenance support following restart.

4.6 Restart Test Program

See NUREG-1232, Volume 3.

4.7 Training Program

In Section 4.7 of SSER 1, the staff evaluated Section II.2.3 of the BFNPP. This section documents TVA's review of training for operators and engineers. In addition to this evaluation, the staff inspected licensed and nonlicensed training at BFN on a number of occasions (documented by IRs 50-259, 260, 296/86-14, 86-32, 87-26, 88-08, and 89-20). The staff concluded in Section 4.7 of SSER 1 that TVA had fulfilled its BFNPP commitments to establish training for technical staff and engineers. Furthermore, TVA was implementing corrective actions to improve the performance of its operator requalification program at BFN. The effectiveness of these corrective actions was subsequently examined during an NRC inspection, which determined that TVA's requalification program was satisfactory, as documented in IR 50-259, 260, 296/90-OL-01, dated March 22, 1990.

TVA's failure to adequately implement its commitment to provide orientation training for engineers was documented as an NRC finding in IR 50-259, 260, and 296/89-20. TVA notified the staff that the corrective actions necessary to reconcile this deviation from its original commitment were completed. The staff verified the adequacy of TVA's corrective actions and documented the closure of this open inspection finding in IR 50-259, 260, and 296/90-27.

NRC regulations (10 CFR 55.45) require TVA to certify by March 1991 that the BFN simulator has been modified to a plant-referenced simulator. TVA has requested a schedular exemption until December 31, 1991. The staff approved TVA's exemption request by letter dated Janaury 2, 1991.

4.8 Plant Security

In Section 4.8 of Volume 3 of NUREG-1232, the staff concluded that the physical security program (described in Section II.7 of the BFNPP) was acceptable, assuming adequate implementation of the following security-related actions: (1) test security emergency power, (2) reduce the size of the protected area, (3) improve alarm assessment capabilities, and (4) reduce the number of compensatory measures. TVA has since completed each of these actions. The first item was verified by the staff as complete in IR 50-260/89-09. The other security-related actions were examined as part of a routine NRC followup inspection of BFN security program implementation conducted the week of October 29, 1990. This inspection concluded (see IR 50-259, 260, and 296/90-34) that TVA's corrective actions were not adequate. Once TVA completes the additional work needed to resolve the inspection findings, the staff will conduct a final security closeout inspection before restart.

4.9 Emergency Preparedness

In Section 4.9 of Volume 3 of NUREG-1232, the staff concluded that the emergency preparedness program (described in Section II.8 of the BFNPP) was acceptable upon resolution of the following deficiencies identified in IR 50-259, 260, 296/88-30, dated November 15, 1988: (1) inadequate onsite accountability and (2) failure to demonstrate timely and complete emergency information flow within and between emergency response facilities. These deficiencies were resolved by TVA and verified by the staff in IRs 50-259, 260, and 296/88-34 and 89-25, respectively.

It should be noted that TVA is committed to improve the public address and evacuation system at BFN before restart after the upcoming Cycle 6 refueling outage for Unit 2.

4.10 Radiological Control and Chemistry Improvement

In Section 4.10 of Volume 3 of NUREG-1232, the staff concluded that the radiological control and chemistry improvements program (described in Section II.6 of the BFNPP) was acceptable. However, TVA has since revised its previous commitments regarding implementation of the post-accident sampling system (PASS) required by NUREG-0737. By letter dated December 28, 1989, TVA notified the NRC that an interim PASS would no longer be necessary since the permanent system (i.e., final design) would be installed before restart of Unit 2. Furthermore, a permanent PASS would be installed before restart of Units 1 and 3. The staff approves this schedule and considers installation of the final PASS design a Unit 2 restart commitment.

4.11 Upgrading of Procedures

The system of procedures employed at BFN when all three units were shut down had been in place since the initial fuel load and startup of each unit. Previous audits and inspections by TVA and the NRC had identified problems with the content and implementation of procedures that governed a broad spectrum of plant activities (e.g., plant administration, operations, maintenance, surveillance testing).

Some of the more significant deficiencies discovered in BFN's system of procedures, including the procedural change control process, are as follows:

- A clear document hierarchy was not always evident.
- Regulatory and other requirements were not always fully reflected in appropriate procedures.
- Administrative procedures did not reflect the in-place organization, nor did they clearly define duties and responsibilities.
- The system for implementing procedures and ensuring that plant personnel understood procedures was weak.
- In some areas, administrative controls to ensure compliance with procedures were inadequate.

TVA committed in the BFNPP to implement several programs to upgrade procedures. The NRC staff has evaluated and/or inspected each of these TVA programs for BFN. This evaluation consolidates the staff's findings and conclusions regarding TVA's commitments to upgrade procedures at BFN before restart of Unit 2. The program elements of TVA's effort to upgrade procedures are described in the following sections of the BFNPP:

(1) Section 2.4, "Procedure Upgrade Program"

(2) Section 3.4, "Operating Procedures Improvement"

(3) Section 4.1.4, "Maintenance Procedures and Programs"

(4) Section 5.1, "Surveillance Procedure Improvement"

Other procedures involving functional areas such as chemistry, fire protection, security, and the emergency plan were also evaluated and/or inspected by NRC Region II and Office of Nuclear Reactor Regulation (NRR) personnel. However, the quality of procedures for these functional areas were, or will be, assessed as part of the staff's general scope of review for each respective section of the BFNPP.

Programmatic improvements as described in Volume 1 of the revised Corporate Nuclear Performance Plan (CNPP) established basic requirements for nuclear power (NP) programs and procedures. The BFNPP included corrective actions to resolve specific procedure deficiencies at BFN. Additions and changes to BFN and NP procedures were initiated by near-term and long-term programs to upgrade procedures.

Overall efforts to upgrade procedures are directed by a centralized NP organization, the Nuclear Procedures Staff. The Nuclear Procedures Staff has the responsibility and authority to monitor and support the near-term and long-term upgrades of site procedures and instructions. A dedicated BFN procedures group, the site procedures section, was established to ensure that BFN site procedures and instructions were reviewed and revised.

4.11.1 Long-Term Upgrading of Procedures

Procedures identified as requiring development or upgrading but that are not important to restart and operation of BFN will be revised and upgraded as part of a long-term program to develop and implement the Nuclear Procedures System as described in Volume 1 of the revised CNPP.

The long-term effort involves the establishment of a new procedure hierarchy within the NP organization that will provide clear guidance for the conduct of NP activities. The new system of policies, directives, standards, and instructions will be developed to reduce the complexity of the procedures and to produce a well-ordered administrative system of policies and guidance. The program will ensure the identification and incorporation of regulatory requirements, responsibilities, and organizational interactions into all upgraded procedures. This program will use standardized writers' guides so that all formats are consistent among procedures and so that the information within a procedure will be presented clearly and logically. As documents in the new hierarchy are developed, implementation dates will be coordinated between the NP corporate organization and the BFN site to ensure phased implementation in a controlled manner.

For the long-term effort, the BFN site procedures section will be responsible for all aspects of the review, revision, and approval of BFN site procedures and instructions. In addition, to the extent that NP procedures are issued before the restart of BFN Unit 2, the site procedures section will ensure that the requirements of such procedures are incorporated into the BFN procedure system.

The long-term program will extend over several years and will not be completed before Unit 2 restart.

4.11.2 Near-Term Upgrading of Procedures

The near-term effort focused on the correction of specific deficiencies within existing BFN procedures. Actions to be taken to identify and correct procedures requiring revision or development before Unit 2 restart are as follows:

- Correct identified deficiencies or weaknesses in existing site procedures needed to support safe operation.

- Identify those procedures important to safe operation that require revision or development necessitated by completed plant modifications and system walkdown inspections and revise those procedures identified in the workplans that are needed to declare plant systems operable.

- Revise BFN procedures important to safe operation to reflect changes in responsibilities and authorities resulting from organizational changes.

TVA established a Startup Site Procedures List to ensure that all procedures requiring revision or development before Unit 2 restart are completed. The scope of the near-term program included Site Director Standard Practices (SDSPs), plant manager instructions (PMIs), operating instructions (OIs), general operating instructions (GOIs), abnormal operating instructions (AOIs), surveillance instructions (SIs), and maintenance instructions. Guidelines for the format and content of BFN procedures were established by the SDSPs to provide specific direction for procedure and instruction writers. The near-term program is intended to produce a set of procedures for controlling activities at BFN that will include the following:

- Revisions to reflect the new NP organization and the establishment of procedures to effectively manage safety-related activities in support of Unit 2 restart and operation.

- A defined structure for the system of procedures to be used for operation at the time Unit 2 is restarted.

- Improved technical adequacy and workability of OIs associated with key systems.

- Verification that SIs accurately reflect Technical Specification (TS) requirements in the acceptance criteria.

- Vendor manual references in OIs and maintenance instructions.

- Improved procedure controls to require prompt updates to procedures that are found to contain discrepancies or that are found to be incorrect during usage.

- An improved training program to ensure that employees who use the procedures and instructions understand them and know how to use them.

The near-term program will be completed before Unit 2 restart. Reviews and upgrades of OIs and SIs are being completed before Unit 2 restart to ensure the licensee's ability to operate and shut down the plant safely (see Sections 3.4 and 5.1 of the BFNPP). In addition, maintenance procedures will be upgraded as part of the Maintenance Improvement Program (MIP) discussed in Section 4.1.4 of the BFNPP.

4.11.2.1 Administrative Procedures

TVA addressed programmatic issues by improving the implementation and control of procedures and work at BFN. The site procedures section implemented a program to upgrade administrative procedures in the SDSPs and the PMIs. These improvements included a restriction on the use of non-intentional changes, discouraging the use of temporary changes, and a revision to the procedure that governs procedure reviews to require preapproval walkdown inspections and walkdown inspections by the cognizant system engineer and the individual implementing the procedure.

Plant modification procedures require review of the workplans for each engineering change notice (ECN) to identify all related procedures, vendor manuals, and drawings that are affected by a modification. The modification process requires revisions to be made to each affected document before closure of an ECN.

Administrative procedures require that if a procedure does not work, the employee who identifies the discrepancy must (1) promptly report the error, discrepancy, or inadequacy and update the procedure; (2) be alert for conditions not covered in the procedure that could adversely affect the safety of personnel or equipment; and (3) submit recommendations for procedure improvements by a Procedure Change Request (PCR).

Procedure SDSP-7.4, "Procedure Review," establishes the requirements for verification and walkdown reviews, validation, and 2-year reviews of BFN site procedures. This procedure applies to all operating-type instructions such as GOIs, OIs, AOIs, and SIs. Site procedures must be reviewed by a qualified reviewer in accordance with the requirements of SDSP-7.4 before any change. Some of the requirements of SDSP-7.4 specify that (1) all OIs, SIs, and man-machine interface procedures be evaluated for operation and shutdown of the plant and to verify that acceptance criteria are clearly specified; (2) procedures reflect the current site organization; (3) SIs be checked to verify that they accurately reflect TS requirements and that each SI includes associated TS requirements as acceptance criteria; and (4) a validation be conducted during the first performance of a procedure to verify that the task can be completed correctly by following the procedure. Before a technical procedure or an SI can be approved or revised, a walkdown review of the instruction must be completed. The walkdown review must be performed by both a person qualified to perform the procedure and a qualified reviewer, or a licensed reactor operator, or a previously licensed reactor operator, or the cognizant engineer.

TVA has completed upgrading of the SDSPs and the PMIs. The adequacy and use of these procedures have been addressed on a continuing basis during routine inspections by the resident inspectors and during special inspections by various NRC inspection teams. No major discrepancies have been identified during the inspections, and the procedure upgrades have improved the conduct of activities at BFN.

4.11.2.2 Operations Procedures

TVA conducted a thorough review of all Unit 2 and common unit operating procedures and implemented a program to rewrite and verify these procedures (e.g., OIs, GOIs, and AOIs). Operational procedure improvements involved three steps, with the overall objective of improving the accuracy of the procedure, broadening the scope of the procedure, and upgrading the human factors characteristics of the procedures. These three steps included (1) rewriting procedures; (2) management review of the procedures; and (3) exercising selected, revised procedures on the plant simulator to obtain operator feedback and to gain experience with the procedures.

The staff evaluated the BFN operations program and procedures in Section 4.12 of this SSER and concluded that significant progress had been made in the upgrading of the operating procedures. Furthermore, completion of the upgrade program should resolve previously identified procedural problems. However, the staff also noted that current plant conditions provided insufficient opportunity to adequately evaluate the OIs, except for shutdown operations, and that the adequacy of the OIs for power operations will be examined by future inspections.

All operations procedures necessary for the restart and operation of Unit 2 have been upgraded. Not all of the procedures have been validated because the plant is in a shutdown status, with most systems inoperable while undergoing modifications. However, walkdown inspections have been performed for many of the procedures, or the procedures have been exercised through use of the plant simulator.

The samplings of operations procedures examined in NRC inspections to date have shown no major deficiencies. The adequacy of the operating procedures for power operations and the licensed operators' knowledge of procedures will be evaluated as part of the staff's ORAT inspection and during the continuing NRC oversight activities before and after restart of Unit 2.

4.11.2.3 Surveillance Instructions

TVA implemented a program to upgrade all Unit 2 and common unit SIs before Unit 2 restart. In addition, all of the SIs were to be verified and validated to ensure technical adequacy and usability. The process included a validation checklist to be applied after procedure approval, during the first use of the procedure on the simulator, or during a walkdown inspection. This process reinforces the user's involvement in the upgrade process and improves quality by validating actual use of the procedures.

Measures were taken to increase management's attention to and involvement in the TS surveillance program. TVA set requirements for management involvement in field observations, in documentation, and in feedback of the results. TVA also mandated that management would review deficiencies identified during the verification and validation process and concur with subsequent changes to SIs.

The staff evaluated the SI upgrade program in Section 4.4 of Volume 3 of NUREG-1232 and concluded that this program was acceptable. The staff also concluded that the effectiveness of BFN surveillance testing would depend on proper implementation of the corrective actions contained in the SI upgrade program. In Section 4.4, the staff identified the following concerns related to the implementation of the surveillance program: (1) the system engineer concept in relation to the plant surveillance program, (2) SI validation, (3) SI verification, (4) improvement of management practices to foster procedural compliance among personnel, and (5) commitment tracking. These issues will be addressed in a future surveillance team inspection and commitment tracking closeout inspection at BFN.

A special reactive inspection had been conducted in September and October 1989 (IR 50-259, 260, and 296/89-43) to review continuing problems with the implementation of the TS surveillance testing program. Four violations were identified during the inspection involving inadequate SIs, failure to meet SI frequency requirements, failure to maintain TS LCO compensatory measures, and failure to follow SIs. The inspection report noted that violations and LERs issued since January 1988 included inadequate SIs; failure of licensed operators, maintenance craftsmen, and chemistry technicians to follow SIs; failure to meet scheduled testing frequencies; failure to perform SIs implemented as compensatory actions; and failure to implement or maintain compensatory measures required by TS LCOs. This historical review of the multiple problems encountered in the SI program led the inspectors to conclude that BFN was continuing to experience difficulty with both the program and its implementation.

The results of IR 89-43 indicated that the licensee had not made sufficient progress on the SI program upgrade, as evidenced by the breadth, depth, and number of violations cited by NRC and the LERs submitted by TVA. The report noted that the continuing difficulties were potentially indicative of a programmatic breakdown. Furthermore, this report concluded that the surveillance testing program in place at BFN at the time of the inspection would not support the restart of Unit 2. The four violations identified during the inspection were subsequently categorized as a Severity Level III problem; however, a civil penalty was not proposed.

An NRC vertical slice inspection of the core spray system conducted in late 1989 (IR 50-259, 260, and 296/89-16) identified examples of weaknesses in the developmental guidance on procedures at BFN. Procedures were also examined to ensure adequate incorporation of this developmental guidance. This inspection found that surveillance and maintenance procedures appeared adequate for the performance of required tasks. However, a lack of clearly defined criteria in existing reference guides resulted in numerous variations among these procedures and deviations from established guidance.

All Unit 2 and common unit SIs have since been upgraded, and some have been verified and validated. However, because SIs cannot be validated until their first scheduled performance, some will not be validated before restart of Unit 2. These SIs will include long-term SIs (i.e., of a 10-year frequency), SIs that require certain operating conditions in order to be performed, and portions of SIs that require certain operating conditions for performance. TVA has also developed a separate procedure, PMI 17.12, "Surveillance Program Implementation," to provide specific requirements and controls for the TS surveillance testing program.

Because the plant is shut down and defueled, the enhanced SI upgrade program could not be fully evaluated. The adequacy of the surveillance testing program and upgraded SIs will be assessed during a special NRC surveillance program inspection and the ORAT inspection before Unit 2 restart. These inspections will assess the readiness of the SI program to support safe operation of Unit 2 and will determine whether TVA's corrective actions in response to the NRC's escalated enforcement effectively resolved staff concerns regarding the adequacy of the SI upgrade program.

4.11.2.4 Maintenance Procedures

TVA initiated a program to improve the performance of maintenance. This program was designed to evaluate existing activities, to identify needed improvements, and to manage the necessary changes. This program was presented in two parts: (1) a programmatic Maintenance Improvement Program (MIP) and (2) a detailed plan for evaluation and action termed the Maintenance Action Plan (MAP). A maintenance procedure upgrade program was initiated as part of the MIP to ensure that maintenance procedures and instructions were technically accurate, complete, and up to date.

Administrative procedures governing the maintenance program were rewritten as PMI 6.2, "Conduct of Maintenance." The MIP is an ongoing program and is included in PMI 6.2, Section 4.22. The MIP is kept up to date by maintenance personnel. The status of corrective actions identified by the MAP is tracked and monitored.

Samplings of maintenance program outputs and procedures to date indicate a vast improvement in the quality of procedures. A performance-based maintenance team inspection (MTI) was conducted in December 1989 and January 1990 (IR 50-259, 260, and 296/89-56). No major deficiencies were identified, and the team concluded that the maintenance program and its implementation were satisfactory. The team also concluded that the preventive maintenance program, procedures, and SIs reviewed during the inspection were adequate. Plant conditions at the time of the inspection limited the scope of the MTI, and a followup to the MTI will be conducted to review the maintenance program after Unit 2 restart.

The staff SER for maintenance was included in Section 4.5 of SSER 1, which concluded that the MIP (as integrated into PMI 6.2) would be responsive to identified needs for improvement and meets the intent of the proposed revised Commission policy statement on maintenance of nuclear power plants. The staff also concluded that appropriate programs were in place that should support Unit 2 restart if properly implemented.

4.11.3 Conclusions

Overall, NRC inspections have found the TVA programs to upgrade procedures to be effective, except for certain aspects of the SI upgrade program. The staff concluded that the various upgrade programs have resulted in significant procedural improvements and should provide adequate procedures to operate, maintain, and shut down the plant safely. The near-term portion of the upgrade effort is ongoing and will be completed before Unit 2 restart. The site procedures section is tracking the completion of all upgrades. Although substantial activity is under way, the long-term program to upgrade procedures will extend over several years and will not be completed before Unit 2 restart.

Plant conditions (i.e., shutdown) during the procedures upgrade process limited the extent of verification and inspections that could be performed by TVA and the NRC. Several OIs and SIs require that the systems and the plant be operating before they can be tested, and these procedures will be verified during Unit 2 startup or during full-power operation. In addition, the various problems identified with the SI upgrade program and the licensee's corrective actions for these problems will be evaluated. The adequacy of operating procedures will be evaluated as part of the NRC ORAT inspection before Unit 2 restart and by routine NRC oversight activities during Unit 2 startup. The adequacy of the upgraded SIs and TVA's corrective actions pertaining to the NRC enforcement action (EA 89-226) will be evaluated during a special surveillance inspection to be conducted before Unit 2 startup. Furthermore, a followup to the MTI will be conducted after restart of Unit 2 to address maintenance activities during full-power operations.

4.12 Operations

In the development of Section II.3, "Operations," of the BFNPP, TVA analyzed past violations, SALP reports, and INPO recommendations. Poor operating practices in the past had resulted in many NRC violations at BFN. These violations included failure to follow procedures, nonconservative actions by operators, failure to correct known equipment problems, nonconservative TS interpretations, and inadequate procedures. Inadequate management of operations was also evident in the inadequate level of understanding exhibited by senior plant management of issues related to operations, the lack of management involvement in day-to-day operational activities, and the failure of management to take required actions to correct known plant deficiencies. In addition, operations management had been consistently defensive in dealing with NRC, especially when confronted with staff concerns regarding poor performance.

The BFNPP assessment determined that poor operations performance could be attributed to the following four root causes:

- Inadequate management direction and leadership of operations activities.
- Lack of adequate training and rigorous discipline in the conduct of duties by operations personnel.
- Insufficient attention to detail and lack of operational support and followup to correct identified deficiencies.
- Ambiguous and sometimes difficult-to-use procedures.

The BFNPP program for operations identified several action plans for improving operational performance and correcting the root causes identified above. In addition to the BFNPP, TVA also took numerous other actions to improve operations performance. The details of some of the more significant actions are described and evaluated below.

4.12.1 Operations Management Improvement

The operations organization was restructured to address past deficiencies in operations management. The shift operations section was reorganized to provide an operations group primarily assigned to each unit. Each operations group is primarily assigned to a specific unit but may be rotated to other units for training, operations experience, and special assignments.

To enhance management's involvement in day-to-day operations, the number of managers directly reporting to the Operations Superintendent was increased from four to six. This reorganization decreased individual responsibilities and spans of control and increased operations expertise. This change was also intended to provide these managers with more time to be involved in day-to-day problems and to anticipate potential problems. To strengthen operations management expertise and to bring new management perspectives to BFN, three new Unit Operations Managers were hired. These individuals have held Senior Reactor Operator (SRO) licenses and have considerable operational experience with power operations, plant restart, training, procedures, planning, and scheduling. To improve day-to-day oversight, a management observation checklist was established for periodic observations of plant activities by on-shift and off-shift managers. In addition, operations supervisors attend formal shift turnover meetings and also review shift logs daily to maintain awareness of unit operations. Taken together, these management-level changes were intended to improve performance in all aspects of operations and to substantially increase operational readiness.

TVA's reorganization to increase the number of unit managers has increased management's involvement in day-to-day operations. The unit operations managers and supervisors have more time available for thorough analysis and resolution of problems than they had under the previous organization, where a single operations manager was responsible for all three units. Improved management involvement is evidenced by the operations supervisor's involvement in shift turnover meetings. However, none of the operations managers nor any of the managers outside the operations organization maintain an SRO license for the facility.

To aid in eliminating TS violations, operations management implemented a formalized program that tracks LCOs. The tracking program is intended to ensure that all LCOs are documented. LCO tracking is computerized and is controlled by the Shift Operations Supervisor (SOS) and the Shift Technical Advisor (STA) in the main control room.

To improve command and control of unit activities, the SOS was relocated into the main control room area. TVA also created a Shift Support Supervisor (SSS) position to reduce the administrative burden on the SOS. These changes resulted in increased involvement of the SOS in daily operational activities. Other changes, made in response to human factors concerns, involved extensive relabeling of Unit 2 and common control panels by a labeling group tasked with upgrading Unit 1, 2, and 3 plant labels in the future. This group also completed labeling of instrument racks containing reactor protection system and primary containment isolation system instruments.

Management's attention to enhancing operations performance was evident in the planned upgrade of the control room. The completed upgrades included an elevated workstation for the SOS, floor coverings to reduce noise, labeling of annunciators, and better operator aids. Relabeling was especially useful for the annunciator windows as they are now clear and easy to read. Several new operator aids have been put in place. Red and green carpeting has been placed throughout the restricted access areas of the control room.

TVA took measures to enhance training for operations personnel in order to improve the conduct of daily operational activities. For example, requalification training for licensed and nonlicensed personnel was expanded from 4 to 8 weeks. Auxiliary Unit Operator (AUO) training and performance were enhanced by assigning a Training AUO to each shift. In addition, before restart each SOS will participate in INPO peer evaluations at other utilities. These individuals will thus be provided an opportunity to observe and learn how operational activities are conducted at other plants.

Management directed positive attention to solving operations' training needs. The active role by management in upgrading training resulted in an enhanced program to support safe plant operations. The effectiveness of these efforts was demonstrated by the 100 percent pass rate for all those taking the NRC examinations the weeks of January 22 and February 5, 1990. Only 15 of 24 licensed operators passed the requalification examinations administered during the weeks of July 10 and July 17, 1989.

The responsibility for fire protection was also integrated into the operations organization, and the on-duty fire brigade now reports directly to the SOS. This change enhances fire protection by assigning responsibility for the program to the SOS and should improve TVA's ability to control fire protection compensatory measures. Also, integration of the program into operations should enhance communications and interactions between fire protection personnel and operations personnel.

Unit 2 fuel loading in January 1989 was the first major operations activity since the unit was shut down in September 1984. Significant weaknesses were noted during the fuel-loading operations with respect to performance of 10 CFR 50.59 reviews, review and approval of procedures, and application of TSs. A special reactive inspection indicated that the TVA management and operations personnel accepted without question those provisions of TSs that did not preclude unmonitored core alterations. TVA's management emphasized compliance rather than safety in order to accommodate the easiest option in performing the fuel-loading operation. When the problem was initially identified, TVA's assessment and actions were nonconservative and incomplete. Once the full significance of the issues of unmonitored core loading were made known by the NRC and acknowledged by TVA, the corrective actions taken were considered to be conservative and acceptable.

4.12.2 Discipline in the Conduct of Operations

Plant Manager Instruction (PMI) 12.12, "Conduct of Operations," establishes the standards for operator conduct. The PMI also dictates policy and provides instructions for all aspects of plant operation, including shift turnover, communication, watchstanding, procedural compliance, maintenance of logs, and incident critiques.

A policy of strict compliance with procedures is enforced by operations management and is discussed in PMI 12.12. Operations personnel are required to follow procedures strictly unless it is suspected that the procedure is incorrect or that the required actions will degrade equipment or safety. In that case, work stops, the system or component is put into a safe condition, and the appropriate supervisor is notified. When discrepancies in procedures are identified, they are to be reported by a Procedure Change Request (PCR) or corrected with an approved temporary change. This process ensures that the plant is operated safely in accordance with approved procedures and that needed revisions to procedures are identified and made so that procedural errors do not occur. Procedure PMI 12.12 also clearly defines the responsibilities of the SOS and specifies that the on-shift SOS is responsible for all aspects of plant operation, including all maintenance activities and radiological controls, and has authority to control all such activities. This PMI gives authority and clear direction for handling emergency situations.

Operations personnel are encouraged to report problems and improvements to their supervisors so that safe, more efficient methods of operating the plant are identified and implemented.

In general, control room operations have been satisfactory since the plant was shut down, and no major problems have been identified. Proper control room staffing is maintained and shift turnover meetings are formally conducted.

Successful use of the emergency operating instructions was demonstrated during operator examinations and the annual emergency preparedness exercise.

The Unit 2 core offload that occurred during January and February 1990 was performed in a methodical manner and more conservatively than during previous fuel-loading activities.

With the exception of loading fuel and subsequent defueling, few periods of operational activity have occurred. Because the plant has been shut down, the primary role of the operators is merely to monitor the plant. Several of the violations issued by the staff and LERs submitted by the licensee have been classified as surveillance, maintenance, or post-maintenance/modification testing problems. However, on-shift operations personnel could have prevented many of these problems by ensuring system operability, by performing better reviews of paperwork, and by taking a more active and responsive role in eliminating errors.

Continuing problems were noted with compensatory fire protection measures. Although procedures were in place that established a system to control compensatory measures, management's control of the system was ineffective, and operations personnel were not aware of this system.

The operations organization has had trouble responding quickly and adequately to control room alarms associated with off-normal conditions. Several violations occurred involving the loss of large quantities of potentially contaminated reactor-grade water. If initial control room alarms had been adequately acted upon in accordance with the Alarm Response Procedure, these events could have been avoided.

However, more recent observations by the staff during routine inspections have noted significant improvements by licensee management and operations personnel in dealing with testing situations, compensatory fire measures, and control room alarms. Furthermore, these staff concerns identified in the previous paragraphs will be inspected within the scope of the ORAT.

4.12.3 Problem Analysis and Resolution

One aspect of the overall effectiveness of the operations organization is its ability to interact with other relevant site organizations. TVA has taken several specific measures to improve these interactions. One significant change involved the integration of the operations, work control, and chemistry organizations under the oversight of one high-level manager. This should lead to improved work control in each of these areas, with better root cause analysis of problems and greater cohesiveness in the resolution of problems. Site management practices are designed to increase employee awareness and to encourage root cause analysis by all employees to solve plant problems. Operations supervisors have been instructed to analyze problems to determine root causes, to formulate adequate corrective action, and to follow through to see that corrective action is implemented. The unusual event critique, as defined in PMI 12.12, requires the SOS to determine the root cause of events and forward the results to operations management for review. Operations supervisors are also being held responsible for evaluating overall operations practices, identifying root causes of problems, and prescribing long-term solutions.

TVA has implemented its program for incident investigation when an error or a plant event occurs. These investigations included identification of the root cause and corrective actions. Staff reviews of the investigation reports determined that the reports were self-critical and contained good corrective actions. These corrective actions were found to be formally tracked and completed. This rigorous implementation of self-evaluation and corrective action is a strength of the licensee's programs.

The scram reduction program was a positive step in problem resolution. This program included a review of all past scrams between 1978 and 1985. One hundred twenty-two recommendations were made for improvements that could potentially reduce spurious scrams.

Furthermore, the systems engineers provide operations with knowledge of the system and thus permit more attention to be paid to operations issues. Several inspections have found that the system engineer process works well and provides substantial input to plant activities.

4.12.4 Operating Procedures Improvement

Over 20 Operations Section Instruction Letters (OSILs), all supplemental instructions and information to operators, and several standard practices related to operations were deleted. In most cases, the deleted information was covered in other documents, or the information required actions that were unnecessary and that resulted in an additional administrative workload for operations personnel. Standard Practice BF 12.24, "Conduct of Operations" (now PMI 12.12), was written in accordance with INPO and NRC guidelines to consolidate all aspects of shift operations into one instruction to make operating requirements easier to identify and to eliminate discrepancies in administrative procedures. TVA upgraded and incorporated the OSILs into procedures on system status control and equipment deficiency tags. The new procedures incorporate additional management reviews and ensure that operators are aware of equipment status, including problems.

In accordance with the effort to upgrade BFNPP procedures, TVA implemented a program to rewrite and verify the plant operating procedures (Sections II.2.4.3.1 and II.2.4.3.2 of the BFNPP). Operating procedures include operating instructions (OIs), general operating instructions (GOIs), and abnormal operating instructions (AOIs). These procedure improvements were accomplished in three steps with the overall objectives of improving procedure accuracy, broadening procedure scope, and upgrading the human factors characteristics of the procedures.

The first step was to rewrite the procedures. TVA began work on this effort before 1989, assigning writers who had operating experience. TVA continued the rewriting effort in 1989, utilizing plant operations personnel with procedure-writing experience. One emphasis of the rewriting effort was to incorporate background information in the cautionary notes in order to enhance the operator's understanding of the procedures when they are applied in the future. The procedures were rewritten in accordance with established writers' guides.

The second step was a management review. This review was conducted by both new managers and managers with experience at TVA, thus allowing the new managers to apply their perspectives from outside TVA while also allowing longstanding TVA managers to apply their knowledge of BFN.

The third step was to exercise selected revised procedures on the plant simulator to obtain operator feedback and to provide operators experience with the procedures. In addition, the revised procedures have been used in the restart test program. It can also be noted that just recently TVA began to require review of all operations procedure changes by training section personnel. This facilitates training of operations personnel on procedure changes and also provides an objective review of these changes.

In conjunction with the procedure rewriting effort, improvements to the TS were also being made to remove ambiguities, to clearly define requirements, and to improve legibility. The "Standard Technical Specifications for General Electric Boiling Water Reactors" (NUREG-0123) was used as a model for more clearly written and more easily implemented TSs. The proposed TS revisions required for plant restart have been submitted to the NRC for approval.

To minimize future misinterpretation of TSs, most of the TS interpretations on file at the time of the plant shutdown have been cancelled, the remaining interpretations are supported by safety evaluations, and a policy of strict, conservative TS interpretation is being stressed to the operations staff. A Technical Specification Interpretation Committee resolves and documents interpretation questions as they arise to ensure consistent interpretation of questionable areas.

TVA's efforts to upgrade procedures are ongoing and should produce procedures that are both accurate and workable and that improve operations performance.

4.12.5 Conclusions

The staff concluded that the BFNPP assessment of the root causes for operation-related deficiencies was accurate. The staff further concluded that the licensee's corrective actions should help resolve operation's performance problems.

As a result of the additional operational expertise the licensee brought into the operations organization, significant progress was made in the area of compliance with procedures and TS requirements. All of these measures taken together have helped to promote a philosophy conducive to operational readiness.

Although significant progress has been made in improving the conduct of operations in general, some weaknesses still exist, such as personnel error and inadequate adherence to procedures. The numerous personnel errors experienced in the past can only be eliminated by a better operational attitude and a commitment to safety and quality. Program adequacy and safe operations can be achieved by satisfactory implementation of the program and strict adherence to established good operator practices.

An extensive backlog of deviations from primary and critical drawings existed that could have compromised drawing accuracy. However, the drawings are being updated as systems are returned to service, and there will be no backlog at restart.

Finally, current plant conditions (i.e., shut down and defueled) make it very difficult for the staff to evaluate the effectiveness of the licensee's corrective actions for anything but shutdown operations. The adequacy of program implementation and its effect on personnel errors, procedural adherence, and operational readiness for power operations will be addressed by the ORAT and future routine NRC inspections before and during the restart of Unit 2.

5 EMPLOYEE CONCERNS

Sections 5.1 through 5.3 of NUREG-1232, Volume 3, documented the staff's evaluation and multiple inspections of TVA's new Employee Concerns Program (ECP). This program was put into effect at all of TVA's nuclear power plants on February 1, 1986. In Section 5.3, the staff concluded that the ECP constituted an acceptable program for handling employee concerns.

The Employee Concerns Special Program (ECSP), set up to address employee concerns identified before February 1, 1986, was also considered acceptable by the staff. Details of the staff's programmatic evaluation and resultant conclusions regarding TVA's ECSP were documented in the NRC's SER dated October 6, 1987 (issued on the Sequoyah docket). The staff has since reviewed a representative sample of the Employee Concerns Subcategory Reports generated as a result of TVA's ECSP and issued a SER, dated May 31, 1990. This SER concluded that TVA has resolved the employee concerns addressed in the ECSP adequately enough to support restart of BFN Unit 2. In addition, the NRC staff conducted a followup team inspection in November and December 1990 (IR 50-259, 260, and 296/90-31) which verified that the employee concerns addressed by the ECSP were being adequately resolved to support restart of Unit 2.

A supplement to the staff's May 31, 1990, SER is currently under development. This SSER will document additional staff evaluations regarding TVA's program for addressing employee concerns. In particular, the staff reviewed a number of instances in which TVA deviated from its established corrective action programs.

6 ALLEGATIONS

Allegations are statements or assertions of impropriety or inadequacy associated with NRC-regulated activities, the validity of which has not been established. These allegations are normally directed to the NRC staff by individuals or as information referrals from the U.S. Department of Labor (DOL). As of December 31, 1990, the NRC staff had received a total of 18 allegations related to the Browns Ferry facility for calendar year 1990. The allegations were received at a relatively low rate, ranging from zero per month in May and August to five in February. Those received in February included DOL complaints. The NRC staff reviewed and evaluated all allegations and, under certain circumstances, referred them to the licensee for investigation.

There have been only a few allegations of harassment and intimidation (H&I) at BFN. The NRC staff received two harassment allegations, one employment discrimination allegation, and three DOL complaints in 1990. Of the three DOL complaints, one had already been received by the NRC staff regarding alleged harassment. The other two complaints filed with DOL came from different departments of TVA's organization involving alleged employment discrimination and favoritism in promotional opportunities.

Based on a preliminary review of the submitted H&I and employment discrimination allegations, the NRC staff notes that some of the concerns date back to 1988 and 1987 and that the safety concerns identified had resulted in NRC violations. Furthermore, the licensee was cited with a Severity Level II violation and a civil penalty in April 1990 for harassment and intimidation of the former Nuclear Safety Review Staff employees in 1986. There are no new H&I issues that have any significant safety implications associated with restart of Browns Ferry Unit 2.

The NRC staff completed an initial review of all allegations related to BFN. Allegation inspection followups are ongoing for the 17 allegations that remain open. Before the restart of Unit 2, the staff will again review unresolved allegations to identify any potentially significant issues. On the basis of these reviews and the staff's previous activities, such as technical issue reviews and inspections, the staff concludes that all issues of potential safety significance arising from allegations related to BFN have been or will be identified and satisfactorily resolved before restart of Unit 2.

7 CONCLUSIONS

The NRC staff has concluded that the corrective action plans established by TVA's BFNPP (through Revision 2), and other supporting documents referenced in staff SERs, acceptably address deficiencies in the Browns Ferry nuclear program previously identified by TVA and the NRC (see 10 CFR 50.54(f) letter dated September 17, 1985). The staff's detailed findings and conclusions regarding the specific programs and activities described in the BFNPP are documented in Volume 3 of NUREG-1232 and both of its supplements. Appendix C of this SSER provides a useful summary of the 10 CFR 50.54(f) issues and SALP functional areas as cross-referenced against applicable sections of the BFNPP and NUREG-1232, Volume 3. Although the NRC staff has completed its safety evaluations of TVA's BFNPP, a number of the improvement programs and/or corrective activities are yet to be fully implemented by TVA. Consequently, the staff has not completed all the inspections currently planned to verify that TVA has successfully implemented its BNFPP commitments. When the final elements of TVA's corrective action plans described in the BFNPP are fully implemented, and verified by staff inspections, TVA will be in a position to restart and operate BFN Unit 2 in a safe and responsible manner that will not adversely affect the public or the environment.

In general, the staff's SER findings and conclusions (documented in NUREG-1232, Volume 3 and its supplements) regarding BFNPP programs will also apply to BFN, Units 1 and 3. However, both TVA and the staff will have to evaluate and determine the applicability of these programs for Units 1 and 3 before their respective restart.

At the time of publication of this SSER, final implementation and/or inspection of several Unit 2 restart items remained outstanding as detailed in Sections 2 through 6. However, all programmatic safety evaluations regarding TVA's BFNPP for Unit 2 are currently complete. The staff does not foresee the necessity for any further supplements to NUREG-1232, Volume 3. The few remaining open restart items are awaiting implementation by the licensee and verification by the staff. TVA continues to utilize its Tracking and Reporting of Open Items System for controlling the status of all BFN restart commitments. The NRC, principally Region II, maintains control of all future inspections via a Master Inspection Plan. TVA and the NRC will continue to utilize the Tracking and Reporting of Open Items System and the Master Inspection Plan to provide sufficient assurance that the remaining restart open items are adequately tracked and closed.

In addition, TVA is hereby requested to formally notify the NRC, before the Commission meeting on restart of Unit 2, that (1) all BFNPP corrective action commitments required to support restart are fully implemented and (2) all restart open items identified by the staff in NUREG-1232, Volume 3 and its SSERs, are resolved and/or implemented. Should TVA take exception to any open restart issue identified by the staff, or reconsider any BFNPP commitment required for restart, TVA is to notify the NRC as soon as possible and provide an appropriate justification.

Furthermore, with regard to the outstanding post-restart issues identified by NUREG-1232, Volume 3 and its supplements (including any inspection reports and safety evaluation reports referenced therein), the staff hereby requests that TVA submit a letter within 120 days after restart of Unit 2 that (1) confirms the status of all post-restart open items and (2) provides a schedule for their completion.

APPENDIX A

LIST OF NRC CONTRIBUTORS

Name	Office
T. Cheng	Nuclear Reactor Regulation
P. Cortland	Nuclear Reactor Regulation
J. Fair	Nuclear Reactor Regulation
H. Garg	Nuclear Reactor Regulation
G. Gears	Nuclear Reactor Regulation
G. Georgiev	Nuclear Reactor Regulation
G. Hubbard	Nuclear Reactor Regulation
A. Ignatonis	Region II
K. Ivey	Region II
S. Kim	Nuclear Reactor Regulation
E. Marinos	Nuclear Reactor Regulation
D. Moran	Nuclear Reactor Regulation
C. Patterson	Region II
F. Paulitz	Nuclear Reactor Regulation
R. Pierson	Nuclear Reactor Regulation
T. Ross	Nuclear Reactor Regulation
D. Smith	Nuclear Reactor Regulation
D. Terao	Nuclear Reactor Regulation
R. Wescott	Nuclear Material Safety and Safeguards
F. Witt	Nuclear Reactor Regulation

APPENDIX B

REFERENCES

NRC Letters

U.S. Nuclear Regulatory Commission, August 20, 1980, letter from T. Ippolito to H. Parris (TVA), regarding NUREG-0661, Mark I containment long-term program safety evaluation resolution.

---, September 17, 1985, letter from W. J. Dircks to C. H. Dean, Jr. (TVA), transmitting fifth SALP review and requesting information pursuant to 10 CFR 50.54(f).

---, October 6, 1987, letter from J. Zwolinski to S. A. White (TVA), providing Safety Evaluation of TVA's Employee Concerns Special Program.

---, November 27, 1987, letter from G. Zech to S. A. White (TVA), providing the conclusions from a staff review of Section IV of the Browns Ferry Nuclear Performance Plan.

---, April 13, 1988, letter from S. Richardson to S. A. White (TVA), forwarding Inspection Report (IR) 50-327 and 328/88-07.

---, July 26, 1988, letter from S. Black to S. A. White (TVA), providing a safety evaluation of the interim operability criteria for the seismic design program.

---, August 10, 1988, letter from S. Black to S. A. White (TVA), requesting additional information on the ampacity program.

---, September 1, 1988, letter from S. Richardson to S. A. White (TVA) forwarding IR 50-259, 260, and 296/88-11.

---, September 19, 1988, letter from S. Richardson to S. A. White (TVA), providing conclusions from additional staff reviews of Section IV of the BFNPP.

---, November 15, 1988, letter from F. McCoy to S. A. White (TVA), forwarding IR 50-259, 260, and 296/88-30.

---, November 21, 1988, letter from S. Black to S. A. White (TVA), requesting additional information on electrical issues.

---, December 8, 1988, letter from S. Black to O. D. Kingsley (TVA), regarding Appendix R safe shutdown analysis.

---, December 8, 1988, letter from S. Black to O. D. Kingsley (TVA), providing a safety evaluation of TVA's response to Generic Letters 84-11 and 88-01.

---, December 9, 1988, letter from F. McCoy to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/88-34.

---, December 30, 1988, letter from S. Black to O. D. Kingsley (TVA), approving temporary exemption for General Design Criterion (GDC) 17.

---, March 21, 1989, letter from S. Black to O. D. Kingsley (TVA), requesting that TVA conduct ampacity code test case analyses.

---, March 31, 1989, letter from L. Watson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-09.

---, April 19, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/88-38.

---, May 18, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-15.

---, June 30, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-07.

---, July 17, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-31.

---, July 18, 1989, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-25.

---, August 1, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-13.

---, August 4, 1989, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-20.

---, September 15, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-28.

---, September 21, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-36.

---, September 29, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-29.

---, October 13, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-39.

---, November 2, 1989, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-43.

---, November 3, 1989, letter from S. Black to O. D. Kingsley (TVA), providing supplemental safety evaluation of Appendix R safe shutdown analysis and National Fire Protection Association deviations.

---, November 7, 1989, letter from D. Crutchfield to O. D. Kingsley (TVA), providing conclusions from further staff reviews of Section IV of the BFNPP.

---, November 8, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-32.

---, December 11, 1989, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-44.

---, December 19, 1989, letter from S. Black to O. D. Kingsley (TVA), providing safety evaluation of cable ampacity program.

---, December 21, 1989, letter from S. Black to O. D. Kingsley (TVA), providing safety evaluation of emergency diesel generators.

---, December 21, 1989, letter from S. Black to O. D. Kingsley (TVA), providing safety evaluation of TVA response to GL 88-01.

---, January 30, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-57.

---, February 2, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-61.

---, February 16, 1990, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-62.

---, February 23, 1990, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-59.

---, February 26, 1990, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-260/89-42.

---, March 9, 1990, letter from B. D. Liaw to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-16.

---, March 22, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-OL-01.

---, March 26, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/89-56.

---, April 3, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-06.

---, April 26, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-09.

---, May 11, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-11.

---, May 31, 1990, letter from S. Black to O. D. Kingsley (TVA), providing a supplemental safety evaluation of ECSP Subcategory Reports.

---, July 31, 1990, letter from T. Ross to O. D. Kingsley (TVA), providing safety evaluation of BFN site organization and management.

---, August 10, 1990, letter from S. Varga to O. D. Kingsley (TVA), forwarding IR 50-260/90-13.

---, August 13, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-20.

---, August 22, 1990, letter from T. Ross to O. D. Kingsley (TVA), providing a safety evaluation of heating, air conditioning, and ventilation ductwork and supports inside the chimney.

---, October 24, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-27.

---, November 30, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-36.

---, December 14, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-34.

---, December 14, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-22.

---, December 17, 1990, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-260/90-33.

---, January 2, 1991, letter from F. Hebdon to O. D. Kingsley (TVA), transmitting schedular exemption from 10 CFR 55.45(b).

---, January 8, 1991, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-37.

---, January 14, 1991, letter from B. Wilson to O. D. Kingsley (TVA), forwarding IR 50-259, 260, and 296/90-31.

<u>NRC Meeting Summaries</u>

U.S. Nuclear Regulatory Commission, May 17, 1988, NRC summary of meeting on ampacity issues held April 26, 1988.

---, July 12, 1988, NRC summary of meeting on BFNPP commitments held June 20, 1988.

---, February 15, 1989, NRC summary of meeting on ampacity program held February 2, 1989.

---, August 19, 1989, NRC summary of meeting on control rod drive piping load factors held July 7, 1989.

---, August 21, 1989, NRC summary of meeting on ampacity program held July 10, 1989.

---, December 22, 1989, NRC summary of meeting on cable installation program held December 18, 1989.

---, January 29, 1990, NRC summary of meeting on cable installation program held January 18, 1990.

TVA Letters

Tennessee Valley Authority, November 1, 1985, letter from C. H. Dean, Jr., to W. J. Dircks (NRC), forwarding Corporate Nuclear Performance Plan (Volume 1) and Sequoyah Nuclear Performance Plan (Volume 2).

---, August 28, 1986, letter from S. A. White to L. Zech (NRC) submitting the BFNPP.

---, July 1, 1987, letter from S. A. White to NRC, submitting Revision 1 of the BFNPP.

---, January 25, 1988, letter from R. Gridley to NRC, submitting ampacity evaluation program.

---, March 1, 1988, letter from R. Gridley to NRC, committing to complete TMI Action Plan Item II.K.3.18 before restart.

---, July 7, 1988, letter from R. Gridley to NRC, submitting Revision 1 of ampacity evaluation program.

---, July 18, 1988, letter from R. Gridley to NRC, submitting summary report of cable installation issues.

---, September 29, 1988, letter from R. Gridley to NRC, submitting results of cable testing.

---, September 30, 1988, letter from R. Gridley to NRC, submitting response to a staff request for additional information dated August 10, 1988.

---, October 24, 1988, letter from S. A. White to NRC, submitting Revision 2 of the BFNPP.

---, December 9, 1988, letter from R. Gridley to NRC, submitting response to a staff request for additional information regarding electrical issues.

---, December 15, 1988, letter from R. Gridley to NRC, requesting exemption from GDC 17.

---, December 23, 1988, letter from R. Gridley to NRC, submitting supplemental and clarifying information regarding "Operational Readiness."

---, January 6, 1989, letter from R. Gridley to NRC, submitting report on cable separation.

---, January 20, 1989, letter from R. Gridley to NRC, submitting results of emergency diesel generator load testing.

---, March 15, 1989, letter from R. Gridley to NRC, regarding the maintenance improvement program.

---, March 17, 1989, letter from R. Gridley to NRC, regarding ampacity program.

---, April 18, 1989, letter from C. Fox to NRC, regarding ampacity program.

---, April 27, 1989, letter from C. Fox to NRC, submitting results from ampacity computer code analyses.

---, June 9, 1989, letter from M. Medford to NRC, submitting Revision 1 of the cable separation report.

---, June 16, 1989, letter from M. Ray to NRC, submitting schedular commitments for implementation of TMI Action Plan Items.

---, June 19, 1989, letter from M. Ray to NRC, transmitting results from the cable installation walkdown inspections.

---, June 30, 1989, letter from M. Ray to NRC, submitting supplemental response to GL 88-01.

---, August 14, 1989, letter from M. Ray to NRC, regarding corrective plans for instrument sensing lines.

---, August 18, 1989, letter from M. Ray to NRC, submitting flexible conduit program.

---, August 22, 1989, letter from M. Ray to NRC, submitting response to IR 89-07 findings.

---, October 4, 1989, letter from M. Ray to NRC, submitting information regarding the use of unqualified containment coatings.

---, October 6, 1989, letter from M. Ray to NRC, confirming secondary containment design, testing, and modifications.

---, October 6, 1989, letter from M. Ray to NRC, transmitting results of ampacity analyses.

---, October 23, 1989, letter from M. Ray to NRC, submitting Revision 2 of the cable separation report.

---, November 6, 1989, letter from M. Ray to NRC, submitting followup response to IR 50-260/89-36.

---, December 11, 1989, letter from M. Ray to NRC, regarding seismic qualification of control rod drive hydraulic piping.

---, December 14, 1989, letter from M. Ray to NRC, submitting Revision 3 of the cable separation report.

---, December 28, 1989, letter from M. Ray to NRC, notifying the NRC that a permanent post-accident sampling system would be installed before Unit 2 restart.

---, January 31, 1990, letter from E. Wallace to NRC, submitting an application to amend the emergency diesel generator technical specifications.

---, February 5, 1990, letter from M. Ray to NRC, submitting cable installation test program.

---, March 16, 1990, letter from M. Medford to NRC, submitting corrective action plans that address seismic-related open items from IR 50-260/89-44.

---, May 1, 1990, letter from E. Wallace to NRC, committing to revise human factor considerations in the ongoing probabilistic risk assessment being conducted in accordance with GL 88-20.

---, May 24, 1990, letter from E. Wallace to NRC, confirming capability of residual heat removal system pumps to provide short-term cooling during the design-basis accident.

---, June 11, 1990, letter from P. Carier to NRC, confirming TVA's readiness for the equipment qualification team inspection.

---, July 10, 1990, letter from E. Wallace to NRC, submitting cable installation testing report.

---, July 13, 1990, letter from E. Wallace to NRC, submitting supplemental information regarding GL 88-01.

---, July 13, 1990, letter from E. Wallace to NRC, submitting TS amendment application regarding Unit 3 emergency diesel generator operability.

---, July 13, 1990, letter from M. Medford to NRC, requesting a temporary exemption from 10 CFR 55.45(b)(iii) and (iv).

---, September 18, 1990, letter from E. Wallace to NRC, requesting closure of the Regulatory Performance Improvement Program.

---, September 19, 1990, letter from E. Wallace to NRC, submitting supplemental cable installation testing report.

---, October 2, 1990, letter from E. Wallace to NRC, confirming implementation of the Long-Term Torus Integrity Program was complete for Unit 2.

---, October 4, 1990, letter from E. Wallace to NRC, notifying NRC that torus wide-range level instrument sensing lines had been modified.

---, October 4, 1990, letter from E. Wallace to NRC, submitting supplemental cable installation testing report.

---, October 26, 1990, letter from E. Wallace to NRC, providing the status of staff open items contained in NUREG-1232, Volume 3 and Supplement 1.

---, January 3, 1991, letter from E. Wallace to NRC, forwarding a supplement to TVA's October 26, 1990, letter.

---, January 23, 1991, letter from P. Carier to NRC, providing TVA's operability determination of Brand Rex cables.

NRC Publications

U.S. Nuclear Regulatory Commission, Bulletin 79-02, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts," March 8, 1979; Revision 1, June 21, 1979; Supplement 1 to Revision 1, August 20, 1979; Revision 2, November 8, 1979.

---, Bulletin 79-14, "Seismic Analysis for As-Built Safety-Related Piping Systems," July 2, 1979; Revision 1, July 18, 1979; Supplement [1], August 15, 1979; Supplement 2, September 7, 1979.

---, Generic Letter 84-11, "Inspections of BWR Stainless Steel Piping," April 19, 1984.

---, Generic Letter 87-02, "Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46," February 19, 1987.

---, Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping," January 25, 1988.

---, Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," November 23, 1988.

---, NUREG-0123, "Standard Technical Specifications for General Electric Boiling Water Reactors (BWR/5)," Revision 3, December 1980.

---, NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.

---, NUREG-0737, Supplement 1, "Clarification of TMI Action Plan Requirements (Related to Emergency Response Capability)," transmitted via GL 82-33 issued December 17, 1982.

APPENDIX C

TVA RESPONSES PERTAINING TO BROWNS FERRY 10 CFR 50.54(f) CONCERNS

The NRC's September 17, 1985, 10 CFR 50.54(f) letter requested certain information from TVA regarding the corrective actions necessary to resolve staff concerns related to TVA's performance of nuclear activities. The Nuclear Performance Plan, Volume 3, specifically addresses TVA's responses to this letter as it pertained to BFN Unit 2. The following provides each 10 CFR 50.54(f) concern related to BFN with the corresponding reference to TVA responses as provided in the BFNPP (through Revision 2). An appropriate reference to the staff's safety evaluations of these responses is also provided (i.e., NUREG-1232, Volume 3 and its SSERs).

A. Responses to information requested by Enclosure 2 of the 10 CFR 50.54(f) letter.

1. "Describe the site management changes made subsequent to the SALP period to strengthen the regulatory performance at Browns Ferry, including experience and qualifications of newly assigned managers."

   Nuclear Performance Plan, Volume 3: Sections II.1, II.2, and Appendix C
   NUREG-1232, Volume 3, SSERs 1 and 2: Sections 4.1 and 4.2

2. "Provide a detailed description of the Operational Readiness Plan developed by you to assess the readiness for resuming operation of any of the Browns Ferry units. If this plan does not address all Category 3 areas in the attached SALP report, then your submittal should address these areas. Additionally, because the Regulatory Performance Improvement Program has proven to be ineffective in improving performance, provide an evaluation of the cause of the lack of positive results. Further, provide your rationale for expecting any different results from the Operational Readiness Review."

   Nuclear Performance Plan, Volume 3: Section V and Appendix A
   NUREG-1232, Volume 3, SSERs 1 and 2: Sections 4.1 and 4.2

   With regard to the Regulatory Performance Improvement Program (RPIP), TVA described the reasons why the RPIP was ineffective in Appendix A of the BFNPP. TVA also indicated that the management plan delineated in Sections II.1 and II.2 of the BFNPP (reviewed by NRC in NUREG-1232, SSER 2, Section 4.2) described the actions necessary to address the causes of this ineffectiveness. Furthermore, Appendix A provided the status of the remaining RPIP open items. The staff has conducted a number of inspections and meetings with TVA on implementation of and arriving at final closure of the RPIP. As a consequence, TVA issued a letter dated September 18, 1990, which requested the NRC to close the confirmatory order (EA 84-54, dated July 13, 1984) that required TVA to implement the RPIP for BFN, based on subsequent resolution of all the open RPIP items. The staff conducted a special inspection confirming that the final open RPIP items have been resolved satisfactorily, as documented in IR 50-259, 260, and 296/90-37. Following a final staff review, closure of the RPIP order, if warranted, will be accomplished by separate correspondence before Unit 2 restart.

3. "Provide: (a) a detailed description of the Maintenance Improvement Program including improvements for planning and scheduling maintenance activities and (b) a report on progress and results achieved in implementing this program."

   Nuclear Performance Plan, Volume 3: Section II.4
   NUREG-1232, Volume 3, SSERs 1 and 2: Section 4.5

4. "Provide an updated integrated schedule for all NRC-required plant modifications and improvement modifications which may impact the former."

   Nuclear Performance Plan, Volume 3: Section II.9 and Attachment IV
   NUREG-1232, Volume 3, SSERs 1 and 2: Sections 4.1, 4.2, and Appendix E

   TVA has indicated in Volume 3 that the integrated schedule approach has been superseded by the Volume 3 scheduling effort to support Unit 2 restart. Therefore, the original integrated scheduling effort (submittals of August 14 and September 21, 1984, and April 12, 1985) is no longer applicable. NRC considers this approach responsive to the staff's concern.

5. "Provide analyses that demonstrate that seismic supports with identified deficiencies comply with the seismic design criteria or provide technical justification for interim operation and a schedule for completing any necessary modifications."

   Nuclear Performance Plan, Volume 3: Section III.3
   NUREG-1232, Volume 3, SSERs 1 and 2: Section 2.2

6. "Provide a detailed description of the design control survey which you are conducting, including a discussion of any generic implications on plant design."

   Nuclear Performance Plan, Volume 3: Sections III.2 and III.4
   NUREG-1232, Volume 3 and SSERs 1 and 2: Section 2.1

7. "Provide your evaluation and proposed disposition of recommendations by contractors, such as General Electric, that have evaluated modifications to Browns Ferry safety systems."

   Nuclear Performance Plan, Volume 3: Appendix B
   NUREG-1232, Volume 3, SSER 2: Appendix D

8. "Provide a detailed description of (a) the program being implemented to demonstrate compliance with 10 CFR 50.49 and (b) the long-term program to assure continued compliance with regulations. Affirm that the list of equipment required to meet 10 CFR 50.49 is complete."

Nuclear Performance Plan, Volume 3: Section III.1
NUREG-1232, Volume 3 and SSERs 1 and 2: Section 3.2

9. "Provide an evaluation of the need to establish an onsite independent safety engineering group to review operational events as they occur."

   Nuclear Performance Plan, Volume 3: Section II.1.2.10.1
   NUREG-1232, Volume 3, SSER 1: Section 4.2.2

10. "Provide responses to our requests for additional information and responses to our comments on proposed licensing actions as requested in letters from D. B. Vassallo to H. G. Parris dated November 26, 1984; June 27, 1985; July 22, 1985; July 26, 1985; August 9, 1985; and August 22, 1985."

    Nuclear Performance Plan, Volume 3: Appendices A and E

    TVA's responses to the aforementioned letters were considered acceptable by the staff. Each of the associated licensing actions was subsequently approved by the staff by separate correspondence, or in one case, withdrawn by the licensee.

11. "In addition to meeting the requirements of Appendix R, provide an evaluation of your progress and results achieved in implementing an effective Fire Protection Program that conforms to general industry practice and the fire protection standards promulgated by the National Fire Protection Association (NFPA). Specific weaknesses in your Fire Protection Program have been identified in the attached SALP report and in your own audits."

    Nuclear Performance Plan, Volume 3: Section III.5
    NUREG-1232, Volume 3 and SSERs 1 and 2: Section 3.1

B. Responses on TVA's improvement regarding the SALP Functional Areas.

1. Plant Operations

   Nuclear Performance Plan, Volume 3: Section II.3
   NUREG-1232, Volume 3, SSER 2: Section 4.12

2. Radiological Controls

   Nuclear Performance Plan, Volume 3: Section II.6
   NUREG-1232, Volume 3: Section 4.10

3. Maintenance

   Nuclear Performance Plan, Volume 3: Section II.4
   NUREG-1232, Volume 3, SSERs 1 and 2: Section 4.5

4. Surveillance

   Nuclear Performance Plan, Volume 3: Section II.5
   NUREG-1232, Volume 3 and SSER 2: Section 4.4

5. Fire Protection

   Nuclear Performance Plan, Volume 3: Section III.5
   NUREG-1232, Volume 3 and SSERs 1 and 2: Section 3.1

6. Emergency Preparedness

   Nuclear Performance Plan, Volume 3: Section II.8
   NUREG-1232, Volume 3 and SSER 2: Section 4.9

7. Security

   Nuclear Performance Plan, Volume 3: Section II.7
   NUREG-1232, Volume 3 and SSER 2: Section 4.8

8. Training

   Nuclear Performance Plan, Volume 3: Section II.2.3
   NUREG-1232, Volume 3, SSERs 1 and 2: Sections 4.2 and 4.7

9. Quality Programs and Administrative Controls Affecting Quality

   Nuclear Performance Plan, Volume 3: Section II.2
   NUREG-1232, Volume 3 and SSER 2: Sections 4.2 and 4.3

10. Licensing

   Nuclear Performance Plan, Volume 3: Section II.1.2.10
   NUREG-1232, Volume 3, SSER 2: Section 4.2

APPENDIX D

CONTRACTOR RECOMMENDATIONS

In March 1984, as part of TVA's effort to improve its plants, several outside contractors were employed to evaluate key areas of the Browns Ferry nuclear program. In a letter dated September 17, 1985, the NRC requested, pursuant to 10 CFR 50.54(f), that TVA furnish information to resolve 11 general areas of concern (Appendix C outlines these concerns). One concern involved TVA's evaluation and proposed disposition of recommendations made by contractors such as General Electric Co. (GE) that have evaluated modifications to Browns Ferry safety systems. TVA's response to this request came in the form of the Browns Ferry Nuclear Performance Plan (BFNPP). Appendix B to the BFNPP discusses TVA's responses to the recommendations from GE and from Science Applications International Corporation (SAIC) concerning Technical Specifications.

The staff reviewed the licensee's resolution of contractor recommendations as part of its inspection activities. In particular, IR 50-259, 50-260 and 50-296/89-61, dated February 2, 1990, and IR 50-259, 50-260 and 50-296/89-16, dated March 9, 1990, examined TVA's implementation of the GE report. The staff drew the following conclusions in IR 89-61:

> This item [Unresolved Item (URI) 50-259, 50-260, and 50-296/85-39-04, "Licensee Resolution of GE Report Safety Related Items"] had been opened to track the licensee's resolution of a large number of documented hardware, procedural, and other deficiencies and recommendations identified during an onsite review performed in 1984 on vendor supplied NSSS [nuclear steam supply systems] and other systems by GE personnel. The resident inspectors had identified in IR 85-39, during a followup inspection of the status of these recommendations, that the licensee had not developed a coordinated program for resolution of these deficiencies. Subsequent to this, in a NRC request for information pursuant to 10 CFR 50.54(f), dated September 17, 1985, the NRC asked for an evaluation and proposed disposition of contractor recommendations. TVA responded to this request in the NPP (Volume 3) [BFNPP] Appendix B, Evaluation of Contractor Recommendations.
>
> Additional followup inspections of the implementation of the above commitment was conducted by the resident inspectors and documented in IRs 87-20, 88-16, 88-21, and 89-16. As documented in IR 87-20, the inspectors identified various problems with classification of items as restart, with failure to include all contractor findings in the licensee's tracking program, and other problems including the lack of timely resolution on items that had been tracked for extended periods. During the later inspections, the inspectors continued to follow up on licensee progress in this area, reviewed the licensee's established restart determinations and completion status for selected items associated with System 63, SLC [standby liquid control] System. The inspectors determined that improvements had been made in the

tracking of outstanding items in this area and that the new computer tracking list did not appear to be missing any of the original recommendations. The inspector did not identify any punchlist items that appeared to be improperly classified in accordance with the restart criteria.

The inspector reviewed completed Site Quality Surveillance Monitoring Reports QBF-S-88-1385, dated October 19, 1988, and QBF-S-88-1005, dated August 23, 1988. These internal licensee inspections were performed to satisfy the NPP Volume III Section IV [BFNPP Section IV] commitment and to provide independent verification of the GE Contractor Recommendations. During these inspections licensee QA personnel selected samples from the list of recommendations and verified that the items were properly classified according to the established restart criteria, and that the recommendations were adequately implemented. No problems were identified during the performance of either of these monitoring reports.

On October 13 - November 9, 1989, the licensee performed Quality Audit BFA 89003, Technical Evaluation of the RHR [residual heat removal] System. This audit was performed by licensee corporate QA personnel and was intended to assess the functional adequacy of this system, i.e, similar to an NRC SSFI [safety systems functional inspection]. As part of this inspection the audit team evaluated the GE recommendations that existed with respect to the RHR system. The team determined that the recommendations associated with RHR were divided into 22 specific areas. Each of those areas was reviewed to determine whether the issue presented in the original recommendation was adequately resolved based on the current plant configuration and planned design changes. The team determined that all but one of these recommendations had been adequately resolved. That exception dealt with the recommendation by GE that licensee procedures and methods be established for flushing the RHR heat exchangers with demineralized water and placing the heat exchangers in layup during outages to minimize corrosion that results from extended exposure to river grade water. An Area for Improvement (BFA 890I04003) was opened by the QA organization to track this item.

Inspectors reviewed this area during the NRC SSQE [Safety System Quality Evaluation] performed on System 75, Core Spray, conducted November 27 - December 1, 1989, and December 11-15, 1989. The inspectors reviewed the listing of 37 recommendations and associated dispositions for the Core Spray System. The inspectors selected several recommendations and dispositions from this listing for further review. This review is documented in Inspection Report 89-16. The inspectors determined that in general for the Core Spray System the commitment made in the NPP to disposition the contractor recommendations was adequately accomplished.

Based on the above reviews and the significant effort that the licensee has made in this area, the inspectors determined that the licensee did develop a working program as committed to in the NPP to disposition the contractor recommendations and that a violation or deviation did not occur. This item is closed.

As part of IR 89-16, the staff also examined TVA's closure of the contractor recommendations from SAIC as described in the BFNPP:

> The team reviewed the Science Applications International Corporation's "Evaluation Report on Technical Specification Compliance Effectiveness at Browns Ferry Nuclear Plant," dated September 27, 1984, and verified that the Technical Specifications discrepancies identified for the CS [core spray] system had been adequately resolved.

The staff concluded in IR 89-16, based on examination of TVA's resolution of the GE report and the SAIC recommendations, that the commitments made in the BFNPP to review and dispose of contractor recommendations as requested by the staff's 10 CFR 50.54(f) letter dated September 17, 1985, were adequately implemented to support restart of BFN Unit 2.

APPENDIX E

BROWNS FERRY NUCLEAR PLANT COMMITMENTS

Volume 3 of TVA's Nuclear Performance Plan is the Browns Ferry Nuclear Performance Plan (BFNPP). The BFNPP is TVA's response to the NRC's 10 CFR 50.54(f) letter, dated September 17, 1985, requesting TVA's plans for correcting problems in its conduct of nuclear activities at BFN. The BFNPP identifies the root causes of problems specifically related to Browns Ferry and defines plans for correcting these problems. Section IV, "Summary of Browns Ferry Nuclear Plant Commitments," of the BFNPP summarizes those TVA commitments for BFN that must be completed before restart of Unit 2, those that will be completed as part of a long-term program, and those that will be instituted within ongoing programs. Attachments IV-1, "CNPP Volume I Commitments for BFN," IV-2, "BFNPP Volume 3 Commitments," and IV-3, "Committed Regulatory Modifications Which Will Be Completed Before Restart of Unit 2," of the BFNPP constitute a compendium of commitments made by TVA in the Corporate Nuclear Performance Plan (CNPP), the BFNPP, or other regulatory-related correspondence (e.g., licensee event reports; responses to violations, bulletins, or generic letters; and regulations). As part of NRC's evaluation of the CNPP and BFNPP, SERs (i.e., NUREG-1232, Volumes 1 and 3, and related SSERs) have been issued and inspections have been conducted to examine the effectiveness of TVA's improvement programs, including the specific commitments contained therein.

Any additions to the restart commitments listed in Attachments IV-1, IV-2, and IV-3 that occurred as a result of implementing the corrective action plans of the BFNPP and CNPP were reviewed by a TVA Restart Review Board in accordance with the restart criteria (see BFNPP, Table IV-1, "Restart Requirement Criteria"), which have been approved by the NRC. TVA plans to continue using the restart criteria until fuel load of Unit 2, after which it will utilize a more conventional priority scheme based upon operability requirements (e.g., Technical Specifications). As part of its Operational Readiness Program (see Section 4.1 of this SSER), the licensee has developed a restart commitment closure process, which is being monitored and evaluated by the staff through inspections. Before restart of Unit 2, the staff will make a final determination (i.e., inspection) regarding the effectiveness of TVA's process for tracking and closing those commitments identified in Attachments IV-1, IV-2, and IV-3 of the BFNPP. The staff's determination will be documented in IR 50-259, 260, and 296/90-40.

Attachment IV-4 to the BFNPP ("Committed Regulatory Modifications Which Will Be Completed in the First Refueling Outage Following Unit 2 Restart") has been reviewed by the staff. By letters dated November 27, 1987, July 12, 1988 (NRC Meeting Summary), September 19, 1988, and November 7, 1989, the NRC staff provided its assessments of Attachment IV-4. Those regulatory commitments outlined in Attachment IV-4 that the licensee originally proposed not to implement before Unit 2 restart included Safety Parameter Display Systems (SPDS) (NUREG-0737, Item I.D.2), Post-Accident Sampling System (PASS) (NUREG-0737, Item II.B.3), Qualification of ADS (Automatic Depressurization System) Accumulators (NUREG-0737, Item II.K.3.28), Inadequate Core Cooling Instrumentation/Generic Letter 84-23 (NUREG-0737, Item II.F.2), Detailed Control Room Design Review (DCRDR) (NUREG-0737, Item I.D.1) and Bulletins 79-02 and 79-14.

In response to the staff's letters cited above, the licensee committed by letters dated March 1, 1988, June 16, 1989, and December 28, 1989, to complete all necessary modifications before Unit 2 restart on the following Attachment IV-4 items concerning NUREG-0737: Items II.B.3, II.K.3.28, and II.F.2. At present, only Item II.B.3 remains incomplete. Additionally, TVA's December 28, 1989, letter addressed the status of the two remaining NUREG-0737 items listed in Attachment IV-4, namely, Item I.D.2 (SPDS) and Item I.D.1 (DCRDR). The staff is currently examining the licensee's interim SPDS (Phase I), which is already in place, and is evaluating TVA's proposed final SPDS design description (Phase II) to be installed during the next refueling outage. The staff's findings regarding TVA's interim SPDS will be documented before restart in IR 90-40.

The staff previously evaluated and approved by letter dated September 14, 1989, those portions of the DCRDR program and resultant modifications (concerning human engineering deficiencies [HEDs]) that must be resolved before Unit 2 restart. In addition, TVA has stated by letter dated December 28, 1989, that any additional Unit 2 HEDs (Categories 1 and 2) will be resolved before restart from the next refueling outage. The staff finds this schedule to be acceptable. Furthermore, the staff has just recently examined TVA's implementation of those HED modifications that are required for restart and found them to be acceptable (the staff's findings will be documented in IR 90-40).

The staff's evaluation of the acceptability of the proposed implementation schedule for resolution of IE Bulletins 79-02 and 79-14 is documented in Section 2.2.3.1 of this SSER. In essence, TVA has decided to fully implement these bulletins for Unit 2 by restart time.

Finally, Attachment IV-4 also addresses the Browns Ferry Fire Protection System Upgrade Program. The staff has reviewed implementation schedules for this program (see NUREG-1232, Volume 3, SSER 1 and SSER 2, Section 3.1). By letter dated November 3, 1989, the staff approved the licensee's approach and schedules for compliance with Appendix R to 10 CFR Part 50 as well as compliance with the National Fire Protection Association codes.

APPENDIX F

NRC INSPECTIONS CONDUCTED AT THE BROWNS FERRY NUCLEAR PLANT

The following is an abbreviated list of the more important and unique inspections conducted at the Browns Ferry Nuclear Plant (BFN) over the past several years as part of the NRC's Master Inspection Plan. The inspections are organized by functional titles. The nomenclature used to identify specific inspection reports (IRs) is simply "YY-XX." "YY" represents the last two digits of the calendar year (e.g., 1989 would be "89"), and "XX" is simply an IR specific identifier (i.e., a two-digit number) assigned sequentially during the calendar year as inspections are conducted. Under each functional title a brief synopsis is provided of the inspection subject area and the current status of the inspection as it pertains to Unit 2 restart. It should be noted, in particular, that the routine inspection reports from the resident inspectors (RIs) are not specifically referenced, primarily because of their large number. Appendix F is not a complete listing but a convenient compendium of NRC staff IRs. It is not intended to conflict with or to supplant any of the information or references mentioned in the other sections or appendices of NUREG-1232, Volume 3 and its SSERs (all other sections and appendices have precedence).

A. SITE MANAGEMENT AND ORGANIZATION

The NRC's 10 CFR 50.54(f) letter of September 17, 1985, requested specific information regarding actions taken or planned by TVA to improve management oversight, direction, and support of BFN activities. In response to the 10 CFR 50.54(f) letter, TVA submitted the Browns Ferry Nuclear Performance Plan (BFNPP). In Sections II and IV of this plan, TVA described corrective actions to strengthen management and organization such as (1) restructuring the BFN site organization to achieve compatibility with the corporate structure; (2) preparing position descriptions that delineate areas of responsibility and authority for site management, including reporting channels and interfaces; (3) defining training activities, such as Shift Technical Advisor (STA) training or Senior Reactor Operator (SRO) license training for managers; and (4) establishing specific site improvements, such as a site licensing group.

The following inspections have been conducted:

- Organizational changes: 85-36, RI routine IRs
- Management qualifications: 87-33
- "War Room" and planning and scheduling activities: 87-46, RI routine IRs
- Plant Onsite Review Committee: 85-28, 87-02, 88-05, 88-21, RI routine IRs
- Management training: 89-12
- Nuclear Safety Review Board activities: 87-26, 90-18, 90-14

B. QUALITY ASSURANCE

The NRC's 10 CFR 50.54(f) letter referred to a number of instances of poor performance in the quality assurance (QA) area, including three successive systematic assessment of licensee performance (SALP) periods with ratings of "3" in QA at both Sequoyah and BFN. TVA revised its QA topical report with a number of changes, including (1) restructuring the nuclear QA organization to include a representative at each site reporting to the new Director of Nuclear Quality Assurance, (2) consolidating all nuclear QA and quality control (QC) functions under the Director of Nuclear Quality Assurance, and (3) increasing emphasis on corrective action and root cause analysis programs. The BFNPP, Section II.2.6 and Attachment IV-2, documents TVA's commitments to strengthen QA at BFN. On March 30, 1989, TVA submitted a new Nuclear QA Plan. The major changes in this plan were integration of quality programs, expansion of QA scope to include quality-related activities as well as safety-related activities, incorporation of a graded approach to QA verification, and an update of commitments to American National Standards Institute standards and regulatory guides. This plan has been approved by the NRC.

The NRC staff completed a quality verification inspection (QVI) and a followup QVI in which no significant issues were identified.

The following inspections have been conducted:

- QA program: 86-08, 87-02, 87-20, 90-08
- QA organization and administration: 85-38, 85-48, 86-12, 87-24, 85-47, 87-37
- Audits: 85-38, 88-18, 89-12, 88-04
- Corrective action program: 86-35, 86-36, 86-43, 87-24, 87-37, 87-41, 88-21, 90-36, 90-27
- Q-List: 87-37, 88-05, 88-10, 88-16, 89-16
- QC inspection activities: 86-15
- Document control and records: 85-56, 86-08, 87-37
- QA training: 88-05, 89-12
- Condition adverse to quality report process: 89-10, 90-36
- QVI: 89-12; Followup inspection: 90-20

C. DESIGN BASELINE AND VERIFICATION PROGRAM AND DESIGN CALCULATIONS REVIEWS

Questions were raised during a review conducted for TVA by Gilbert Commonwealth in 1985 regarding the adequacy of the existing TVA design control process. Examples of deficiencies included missing calculations, incomplete design documentation, and failure to update as-built drawings to reflect plant configuration. TVA developed the design baseline and verification program to reestablish the design baseline for BFN as described in BFNPP, Section III.2. This program included (1) establishing the plant configuration, (2) reconstructing the design basis, (3) reviewing and evaluating modifications, (4) defining and performing required tests to verify functionality of DBVP systems, and (5) performing modifications developed from this program.

TVA instituted a review of essential design calculations to verify that the calculations existed and were adequate to support the design of BFN as described by BFNPP, Section III.4. As a result of the calculation reviews, TVA estimated that a large number of calculations would not be retrievable. TVA initiated a review of the engineering calculations in the electrical, nuclear, mechanical, and civil areas.

The staff conducted a major team inspection in October 1987, during which both programmatic and specific deficiencies were identified. The licensee responded to these concerns in April 1988. These responses were reviewed by an NRC team inspection. The staff determined that the DBVP contained the essential elements to achieve its intended goals and objectives. Design calculation inspections have been integrated with those of the DBVP.

The staff evaluation of the DBVP is complete. Sampling of program implementation was performed during a vertical slice inspection (IR 89-16) performed in November and December of 1989.

The following inspections have been conducted:

- DBVP/Configuration Control Management: 86-25, 86-32, 87-02, 87-09, 87-14, 87-20, 87-37, 89-16
- DBVP team inspections: 87-36, 88-07, 89-07
- Design control: 87-08, 88-04, 89-16, 89-17
- Drawing control system training: 86-22
- Calculations: 89-16 (see also "civil calculations" under Section D, "Seismic Issues")
- Modifications: 88-12, 88-19, RI routine IRs

D. SEISMIC ISSUES

Deficiencies were identified for the torus; piping and piping supports; cable tray supports; conduit supports; heating, air conditioning, and ventilation (HVAC) ductwork; drywell steel platforms; miscellaneous steel; lower class over Class I features; secondary containment penetrations; and miscellaneous civil issues. The NRC's 10 CFR 50.54(f) letter requested information regarding the programs being used to evaluate the seismic adequacy of some of these issues. In response to the 10 CFR 50.54(f) letter, TVA submitted its corrective action plans in Section III.3 of the BFNPP, along with other supporting documents.

The following inspections have been conducted:

- Drywell platform steel: 86-14, 86-30, 89-21, 89-29, 89-32, 89-42
- Cable trays: 85-41, 85-51, 86-02, 86-36, 87-07, 87-19
- Pipe supports and restraints: 85-26, 85-30, 85-51, 86-02, 86-19, 87-19, 89-29, 89-44
- IE Bulletins (IEBs) 79-02 and 79-14: 85-21, 85-26, 85-30, 85-41, 86-19, 86-30, 87-07, 87-19, 87-26, 88-12, 88-19, 89-15, 89-44, 89-57, 90-09, 90-26, 90-19
- Conduit and supports: 85-51, 87-07, 87-19, 89-21, 89-29, 89-42
- Control rod drive piping: 86-06, 87-07, 87-08, 87-19, 89-39, 89-42, 89-20, 89-44, 89-62

- HVAC concerns: 86-06, 87-07, 87-14, 87-19, 89-32, 89-42
- Torus attached piping: 87-07
- Small-bore piping: 86-02, 87-07, 89-36
- Secondary containment penetrations: 85-57
- Seismic design programs: 87-27, 88-38, 88-39, 89-29, 89-39, 89-62, 89-21, 89-31, 89-39, 89-42
- Civil calculations: 89-29, 89-30, 89-32, and 89-42

E. ELECTRICAL AND INSTRUMENTATION AND CONTROL ISSUES

Employee concerns, Institute of Nuclear Power Operations (INPO) findings, and various other audits and reviews detected significant deficiencies, which have been categorized as "Electrical Issues." Corrective action plans (BFNPP, Section III.13) consisted of those activities necessary to establish, by analysis or modifications, a plant configuration consistent with requirements of electrical design standards and specifications. The issues involved were ac/dc calculation deficiencies, cable-pulling issues, flexible conduit, cable ampacity, cable separation, thermal overloads, cable splices, fuses, cable and bus protection, diesel generator (DG) component rating, standby DG loading, instrument accuracy, and sensing lines.

The following inspections have been conducted:

- Instrumentation and control: 89-06, 89-12, 89-16, 89-36, 89-59

- Electrical issues: 87-33, 87-37, 86-22, 89-59, 90-13

F. FIRE PROTECTION

TVA described its Fire Protection Improvement Program in Section III.5 of the BFNPP. Final NRC approval of the 10 CFR Part 50 Appendix R safe shutdown program for incorporation into the Technical Specifications is required before restart of Unit 2. Five exemptions from Appendix R requirements have already been requested by TVA and approved by the staff. Modifications to comply with Appendix R will be completed before Unit 2 restart. In addition, BFN has undergone major fire protection upgrades in accordance with the National Fire Protection Association codes.

The following inspections have been conducted:

- Fire protection program: 86-09, 87-21, 89-11, 89-12, 89-33, 90-05, 90-06, 90-11
- Appendix R modifications: 87-37, 89-13, 89-28, 90-06, 90-11

G. ENVIRONMENTAL QUALIFICATION

There was insufficient documentation to demonstrate that electrical equipment at BFN was environmentally qualified as required by 10 CFR 50.49. TVA developed an upgraded environmental qualification (EQ) program (BFNPP, Section III.1) to identify equipment, specify environments, verify equipment in the field, document qualification, specify maintenance requirements, maintain EQ binders, and replace unqualified equipment, if necessary. Any required modifications and final EQ documentation will be completed before restart.

The following inspections have been conducted:

- EQ: 87-26, 87-33, 87-37
- EQ team inspection: 88-11, 90-22

H. WELDING

Concerns were raised at the Watts Bar site regarding TVA's inspection practice and welding rod control program. These concerns implicated the quality of weldments and the ability of the welds to perform their function at BFN. TVA conducted a welding reassessment program at BFN in two phases (see BFNPP, Section III.6). Phase I was a review of the TVA welding program documents (i.e., design documents, policies, and procedures) to ensure that the welding program correctly reflected TVA's licensing commitments and regulatory requirements. Phase II was the actual reinspection of selected welds and weld records.

The welding programs at TVA are administered by a common project group. The NRC reviewed the Sequoyah program and found it acceptable. Both Phase I and Phase II of the welding program have been submitted for BFN and reviewed by the NRC staff. An inspection team inspected Phase I in April 1987 (IR 87-17) and determined that the necessary elements existed to translate welding commitments into specifications and drawings. An inspection team inspected Phase II in May and June 1988 (IR 88-13) and determined that welding was adequately implemented. The team also determined that the corrective actions that resulted from the welding program evaluation appeared adequate and, if properly implemented, should provide reasonable assurance that the quality of the welds at BFN would be adequately verified.

The following inspections have been conducted:

- Welding team inspections: 87-19, 88-13
- Welding program reviews: 86-27, 86-03, 87-14, 90-26
- U2 recirculation safe ends and pipe replacement: 86-17, 86-39, 87-01, 87-04, 87-11, 87-15
- U2 reactor vessel shroud access covers: 88-06, 88-15
- Nondestructive examination: 86-03, 87-15, 87-16
- Reactor vessel nozzle welding: 86-23
  U2 torus modifications: 86-34
- U2 reactor coolant system pipe welding: 85-33
- High-pressure coolant injection welding problems: 85-57
- Core spray system: 89-16

Some aspects of welding were addressed in the vertical slice team inspection. The IEB 79-02/79-14 inspections also reviewed the welding area.

I. TECHNICAL SPECIFICATIONS

TVA and the NRC have identified and agreed upon a list of TS changes requiring approval by the NRC before BFN can enter the startup mode. These changes involve clarifications, corrections, modifications, and organization and regulatory changes. TVA has submitted TS amendment applications for all changes required for restart. TVA completed a TS assessment program to verify compliance with plant hardware, design basis, and NRC safety evaluation. An NRC inspection is planned to verify that the TSs reflect plant configuration, along with training for the changes.

The following inspection has been conducted:

Inspection for TS Adequacy (Phase 1): 89-47

J. INTERGRANULAR STRESS CORROSION CRACKING AND MICROBIOLOGICALLY INDUCED CORROSION

Intergranular stress corrosion cracking (IGSCC) is evident to some degree in all three units. The IGSCC mitigation options are primarily replacement, weld overlay, induction heating stress improvements (IHSIs), and/or hydrogen water chemistry. Unit 2 was inspected to meet the requirements of Generic Letter (GL) 84-11 in 1985 (Temporary Instruction 2515/89). IGSCC mitigation and repair measures on the recirculation and residual heat removal piping implemented on Unit 2 include weld overlay, weld replacement, and welds with shallow cracks mitigated by IHSI (BFNNP, Section III.7). Mitigation steps will be taken for Units 1 and 3 before restart from their current respective outages. TVA recognized the importance of hydrogen water chemistry to mitigate the IGSCC problem, and interface connections are being installed on Unit 2 during this outage to allow mid-cycle introduction of hydrogen water chemistry. The NRC staff performed an onsite review of BFN's IGSCC mitigation program and concluded that TVA is adequately addressing IGSCC at BFN in accordance with GL 88-01. Weld inspections performed subsequent to the post-replacement IHSI of the Unit 2 safe ends are complete.

On September 28, 1988, TVA submitted the Browns Ferry Microbiologically Induced Corrosion (MIC) Program. MIC has been detected at Browns Ferry with small random leaks occurring in high-pressure fire protection and raw service water carbon steel piping, and with MIC indications in emergency equipment cooling water (EECW) piping. The indications in the EECW piping were considered acceptable by TVA for restart.

The following inspections have been conducted:

- IEB 83-02: 86-03
- Facility modifications: 87-30
- MIC: 87-32, 87-33, 87-45
- GL 88-01: 89-05, 89-34
- Shroud supports: 88-06, 88-15
- Jet pump beam assemblies: 84-16

K. PROCUREMENT/PIECE PARTS

From internal TVA reports issued between 1983 and 1985 and during an inspection in November 1986, the NRC determined that TVA had procured replacement parts for safety-related equipment without appropriate procurement controls to ensure that replacement items were tested or qualified for their safety-related applications. TVA has undertaken an extensive program to review and evaluate past and present procurement of replacement items (BFNPP, Section III.12). TVA is establishing the qualification of items or replacing items on equipment required for restart on a priority basis.

The following inspections have been conducted: 85-57, 86-03, 87-08, 87-09, 90-36

L. MAINTENANCE

Programmatic problems in site maintenance were previously identified in SALP and inspection reports. This area received three SALP category "3" ratings. The problems were attributed to such factors as poor supervision of work activities, inadequate planning, ineffective root cause analysis, inadequate training, and poor coordination between different organizations to support maintenance activities. BFN has developed and is implementing a comprehensive Maintenance Improvement Program (MIP) as described in BFNPP, Section II.4. The maintenance team inspection (MTI) in January 1990 concluded that the program and its implementation were satisfactory; however, the ability of parts of the program to support operation could not be evaluated in the plant's current shutdown condition.

The following inspections have been conducted:

- Maintenance program: 86-32, 89-12, 89-16
- MIP: 87-27, 88-02, 89-16, 89-20
- Vendor Manual Control Program: 87-26, 87-27
- Measurement and test equipment: 85-36, 85-53, 86-05, 87-33
- Preventive maintenance: 88-24, 88-28, 88-32, 88-33, 88-35, 89-03, 89-08, 89-11, 89-12, 89-19, 89-20
- Maintenance team inspection: 89-56

M. RESTART TEST PROGRAM

Because of the prolonged plant shutdown and extensive modifications, a comprehensive restart test program (RTP) is required to ensure that plant systems are capable of meeting their safe shutdown requirements. TVA developed an RTP (BFNPP, Section III.8), which included individual and integrated system testing, a backup control test, and criticality and power ascension testing. The DBVP developed the system test requirements necessary to satisfy the safe shutdown analysis. The program involved developing test procedures and, where possible, utilized existing operation and surveillance instructions. A summary description of the program was submitted on July 13, 1987. The staff is in general agreement with the intent of TVA's program and has issued an SER.

The following inspections have been conducted:

- RTP: 87-12, 87-27, 87-30, 87-33, 87-42, 87-46, 88-02, 88-04, 88-05, 88-10, 88-16, 88-18, 88-21, 88-24, 88-28, 88-32, 88-33, 88-35, 89-03, 89-08, 89-11, 89-16, 89-19, 89-20, 89-33, 89-38, 89-53, 90-05

- Restart Review Board: 87-14, 87-30, 87-37, 90-23, 90-27

- Special tests: 86-28, 87-33, 87-42

- Power ascension tests: 90-01, 90-27

N. PROCEDURE UPGRADES

Audits and inspections identified a number of deficiencies and weaknesses in procedures. A procedure upgrade program was implemented to address these problems as described in BFNPP, Section II.2.4. The near-term portion of the program focused on resolving deficiencies in the procedures that affect the safe restart, operation, and shutdown of the plant. Procedures that are not required for restart, operation, and shutdown will be upgraded as part of the long-term program. The MTI rated the maintenance procedures as good. A team inspection of the emergency operating instructions (EOIs) was conducted in August 1988. The vertical slice team inspection reviewed maintenance procedures, surveillance instructions (SIs), operating instructions (OIs), and alarm procedures and reviewed the programs controlling writing and reviewing procedures. Surveillance and operating procedures were reviewed for technical adequacy.

The following inspections have been conducted:

- OIs: 87-09, 87-27, 89-03, 89-16, 89-18
- SIs: 86-14, 87-14, 87-30, 88-02, 89-03, 89-06, 88-24, 89-16, 89-43
- EOIs: 87-46, 88-200, OL-90-01
- Abnormal operating instructions: 87-27, 89-16
- Maintenance procedures: 89-16, 89-56

O. OPERATIONAL READINESS FOR RESTART

A comprehensive effort to assess the BFN plant material condition and personnel readiness to support safe plant restart and operation is required because of the current extended outage, changes in the site and support organizations, realignment of responsibilities, and implementation of new programs to correct past problems. TVA has established programmatic guidance for its operational readiness verification (BFNPP, Section V). On June 16, 1989, TVA issued the first report of a two-phase operational readiness review conducted in May 1989. A second report was issued March 9, 1990, based upon additional reviews. Another independent review will be performed after fuel load to complete BFNPP commitments. The NRC will independently assess TVA's readiness for restart by conducting its own Operational Readiness Assessment Team inspection.

The following inspections have been conducted: 86-14, 86-32, 87-26, 88-36, 89-60

P. TRAINING

From results of NRC requalification examinations, the NRC determined that the TVA operator training program had several programmatic weaknesses. TVA had undertaken a comprehensive one-time training program to upgrade all licensed operators as described in BFNPP, Section II.2.3. Beginning in 1987, TVA increased its annual requalification training for licensed operators from 4 to at least 6 weeks. The TVA BFN simulator was moved to the BFN site to improve operator access to the simulator and to allow for more effective overall training. The licensed operator training program achieved INPO accreditation in March 1986. TVA's programmatic approach was acceptable to the staff. Inspection of the reactor operator training program is complete. NRC requalification testing of TVA operators has also been completed. As a result of a change in the methodology of evaluating the final group, some restrictions have been imposed on these operators pending an evaluation using the "pilot program" techniques.

The following inspections have been conducted: 86-14, 86-32, 87-26, 88-08, 89-12.

The requalification program was reevaluated by the NRC examination process in January and February 1990 and is now judged satisfactory (OL-90-01). All 20 candidates examined at that time passed. Confirmatory Action Letter (CAL) 86-01 was closed in IR OL-90-01.

The following training activities were inspected:

- Overall staff training: 89-58
- Engineering and technical staff training: 89-20, 90-18
- Craftsman training: 89-20
- Operator training on modifications: 90-18

Q. EMPLOYEE CONCERNS PROGRAM

Under the Employee Concerns Special Program (ECSP) initiated at Watts Bar in 1985, more than 5,800 employee concerns were identified. Approximately 700 safety-related and non-safety-related concerns identified in the original Employee Concerns Program (ECP) were applicable to BFN by direct reference or generic applicability. A "new" Employee Concerns Program was implemented on February 1, 1986. The ECP and the ECSP are described by BFNPP, Section II.2.7. Both the ECSP and the new ECP were also thoroughly evaluated and judged acceptable as part of the Sequoyah Unit 2 restart effort.

Inspection activities on the new ECP have been completed. The most recent inspection of the new ECP concluded that the program was adequately established and implemented on site and is acceptable for restart. Additional sampling of the Watts Bar generic concerns is being performed to assure that the corrective actions from the ECSP have achieved the intended results. This inspection effort will be completed with the issuance of IR 90-31.

The following inspections have been conducted:

- ECP: 86-40, 87-26, 87-30, 88-04, 90-05
- ECP team inspection: 88-22
- ECSP team inspection: 90-31

R. RISK ASSESSMENT

As part of the staff's restart evaluation, the Browns Ferry probabilistic risk assessment (PRA) was reviewed in 1986. The licensee considered the

PRA incomplete and a draft, as described in BFNPP, Section III.11. The staff's major concern was to determine whether the plant as modeled in the PRA was an outlier in terms of core-melt frequency when compared to similar plants of similar vintage. The staff met with the licensee in 1988 to resolve this issue. The licensee had revised the draft PRA and had developed a new core-damage analysis. The original PRA had an overall core-melt frequency of 3.9×10^{-3}, which is above the goal of 1×10^{-4}. The revised PRA removed many conservatisms and assumptions, particularly with regard to core melt and human error. These revisions resulted in an overall core-melt frequency of 4.7×10^{-4}.

The following activities have been accomplished:

Staff limited scope review	10/1/87
Staff meeting	5/18/88
Staff audit in Knoxville	3/29/89, 7/10/89

No open restart issues exist with regard to the PRA. In SSER 1, the staff concluded that the Browns Ferry facility is not an outlier with respect to core-melt frequency when compared to similar plants of similar vintage.

The licensee will submit a Level 1 PRA and containment analysis for Browns Ferry by September 1, 1992, to satisfy the Generic Letter 88-20 requirements. This will be a total rework of the existing draft PRA using more advanced computer codes and modeling techniques.

S. EMERGENCY OPERATING INSTRUCTIONS

As part of the Browns Ferry readiness for restart, the adequacy of the EOIs was reviewed by both the NRC staff and TVA. TVA is committed to utilize Revision 3 of the Boiling Water Reactor Owners Group (BWROG) guidance for Unit 2 restart and has committed to upgrade the EOIs to meet the specifications of Revision 4 of the BWROG guidance after restart.

The following inspections have been conducted in this area: 87-46, 88-200, and OL-90-01.

The staff performed an inspection of the EOIs in January 1990 and determined that the operators had been sufficiently trained to the specifications of Revision 3 EOIs. In a January 18, 1990, letter to TVA, the staff identified six items of concern with respect to the Revision 3 EOIs. TVA reviewed each of the concerns and completed corrective actions. TVA's corrective actions were described in a letter to the NRC dated July 6, 1990.

T. ANTICIPATED TRANSIENT WITHOUT SCRAM

In July 1984, 10 CFR 50.62 (the anticipated transient without scram [ATWS] rule) was issued and includes modifications in three areas: (1) recirculation pump trip, (2) standby liquid control, and (3) alternate rod insertion.

In October 1985, TVA submitted to the NRC its proposed solution and schedule for BFN. The BFNPP committed to implement the ATWS rule before Unit 2 restart.

TVA submitted the detailed plant-specific design criteria on July 15, 1988, after submittals on conceptual design and several working-level meetings with the NRC staff. The staff's review was documented in letters to TVA dated January 22 and April 19, 1989. Final modifications of Unit 2 are in progress.

Implementation of the ATWS rule was inspected during the design verification team inspection (IR 89-17, issued August 10, 1989) and in RI IR 90-37.

U. REGULATORY GUIDE 1.97

On December 17, 1982, Generic Letter (GL) 82-33 was issued by the NRC to all licensees of operating reactors. This letter included clarification of Regulatory Guide (RG) 1.97, Revision 2, relating to the requirements for emergency response capability. These requirements have been published as Supplement No. 1 to NUREG-0737, "TMI Action Plan Requirements." TVA provided a response to Section 6.2 of GL 82-33 for BFN on April 30, 1984. Additional information was submitted on May 7, 1985, and August 23, 1988. These responses described TVA's position on post-accident monitoring instrumentation (RG 1.97, Revision 3). The NRC staff reviewed this information and concluded that TVA provided an explicit commitment on conformance to RG 1.97, except for those deviations that were justified.

A Region II team inspection (IR 90-32) was conducted on October 22-26, 1990. The team concluded that TVA had established adequate controls and planning for implementing the RG 1.97 program as committed to for BFN before Unit 2 restart.

V. REGION II SUPPORT INSPECTIONS

The following inspections have been conducted as part of the NRC's routine inspection program:

- Radiological control: 85-27, 85-42, 85-55, 86-10, 86-16, 86-18, 86-26, 86-29, 86-41, 87-28, 87-34, 88-10, 88-14, 88-23, 89-22, 89-33, 89-52, 90-02, 90-21
- Emergency preparedness: 85-23, 86-01, 86-36, 87-18, 87-31, 88-26, 89-14, 90-16
- Emergency preparedness exercise/organization: 85-52, 85-53, 86-32, 86-33, 87-39, 88-30, 88-34, 89-25, 89-41, 89-46, 90-28
- Security: 85-37, 85-46, 85-54, 86-13, 86-21, 86-31, 86-37, 86-44, 87-23, 87-35, 87-44, 88-01, 88-03, 88-20, 88-29, 89-09, 89-23, 89-45, 90-04, 90-12, 90-17, 90-34
- Security/regulatory effectiveness review team: 87-05, 87-23, 88-03, 90-04, 90-17, 90-34
- Security/BFNPP improvements: 87-17, 88-20, 90-17
- Special nuclear materials: 86-38, 87-26, 87-29, 89-01, 89-55

- Bulletin 80-11, "Snubber Surveillance": 89-02, 90-30
- Chemistry: 86-07, 87-06, 87-10, 89-14, 90-02, 90-24
- Inservice inspection: 89-05, 89-34

W. ALLEGATION REVIEW FOR RESTART

Allegations are addressed by the Region II allegation review panel process.

Open allegations will be reviewed before restart. An audit of a sample of closed allegations was performed October-November 1990 to verify adequate closure.

X. REFUELING

The licensee loaded fuel at BFN Unit 2 in January 1989. The major objective was to exercise operations personnel in establishing and maintaining system operability in order to begin the process of establishing the requisite operational attentiveness following an extended shutdown. Unit 2 was defueled in January 1990 to reduce TS requirements to allow modification work to proceed faster. Reload will occur after all restart modifications are complete and after systems required by TSs for refuel are operational.

The following inspections have been conducted: 88-36, 89-03, 89-04, 89-18

APPENDIX G

BROWNS FERRY NUCLEAR PLANT CABLE ISSUES INSPECTION
(SANDIA NATIONAL LABORATORIES)

May 18, 1990

BROWN'S FERRY NUCLEAR PLANT INSPECTION

by J.B. Gardner and W.A. Thue

I. Introduction

We visited BFN plant during the week of April 23, 1990, to assist NRC staff in addressing outstanding pre and post start-up cabling issues for Unit 2. Pullby issues resulting from damage found at WBN was a key issue, but several other issues were addressed as well by observations made during the plant inspection and discussions with TVA electricians and engineers.

II. Procedure

Plant inspections were made to observe some of the worst case pullby conduits that had been selected for dc testing as well as conduits that were selected on the basis of other concerns by the NRC staff. Even in the conduits identified as the most severe, pullby concerns, tests and observations related to other cable concerns were covered simultaneously. These include vertical support, condulets, jamming and side wall bearing pressure damage.

The following section summarizes the findings from inspections at the plant, presents our analysis of all the pullby and other cable issues, presents comments on the March 1989 TVA Summary Report and gives conclusions.

III. Inspection Results

A. Cable Lubrication.

Covers had been removed from boxes and condulets related to the cables being dc tested. In addition, covers had been removed from 11 conduit runs selected by NRC staff. Other work being done in the plant gave additional opportunities to look into a wide variety of other boxes and condulets encountered during the inspection tours.

The only identifiable pulling lubricant seen was "Yellow 77". A few boxes had generous quantities of the yellow material still visible on the cable bundles and in the adjacent conduits. Other possible pull points had only minimal yellow material that was still visible. Only about ten percent of these possible pull points had evidence of abundant pulling compound.

Large quantities of cement dust could be seen inside some of the boxes. This could have masked out the presence of lubricant.

Later pulls that were made with Polywater would give no visible residue.

Discussions with on-site electricians and with engineers established that the normal practice was to clean up excess pulling compound from the cables, boxes and adjacent conduits before placing seals in conduit ends. These seals were present in the majority of the boxes observed.

We therefore conclude from our observations and discussions that pulling compounds were generally used in all pulls. Only in a few cases was evidence available of abundant compound to indicate that a box or condulet was a point of pulling and compound application.

B. Location of Pull Points.

Isometric drawings of the conduits being observed were provided by TVA. These drawings proved to be accurate as to the existence of pull points but not in indicating the nature of bends such as the angle in degrees.

C. Length of Cable Pulls.

The isometric drawings were not to scale nor were the dimensions shown. Using data from their walkdown documents and looking at the isometrics, it was concluded that the TVA data used for tension and side wall bearing pressure calculations was consistent with our field observations for length and bend angles. We did not attempt to make accurate measurement checks but the distances shown in their walkdown papers seemed to be correct.

D. Mechanism for Cable Pullbys.

Almost all open boxes and condulets had one or more 1/C #10 insulated pull wires that obviously were there for use in a pullby. Only the most recent installations did not have these wires in place.

There were no other pulling lines seen - no rope, parachute cord, etc.

The calculated tensions involved in pullbys for the conduits being dc tested and the approximate 100 pound strength of a 1/C #10 insulated wire strongly indicates that some other pull rope must have been utilized for the higher tension pullbys. The wet dc high pot tests will clearly show if such ropes did serious damage.

E. Evidence of Jamming.

There was no visible indication of jamming in any of the boxes that were inspected. These were all relatively short runs which makes the probability of jamming very low.

We generally agree with the March 1989 Summary of Browns Ferry Pulling Concerns and the more detailed Walkdown Report where TVA has analyzed the jamming issue and they state that "jamming is not of concern" at BFN.

Review of their basis for selecting suspect jam conduit runs and their examination of actual potential jamming locations appeared adequate. We concluded that damage from jamming was therefore a satisfactorily low risk for this unit.

F. Severity of Bend Radius.

The pull boxes and condulets inspected were generally quite large so that sharp bends were not necessary and not observed. In two cases of congested cable in junction boxes, the complexity of looping and training of cables was such that control of bending was difficult. Some multi conductor cables may have been at or below the standard bend radius limits. The amount of such bending was minimal and not more severe than commonly observed in other stations.

We reviewed their walkdown report information, their March 1989 Summary Report recommendations and discussed their pre-start action program which included dc high pot testing for MV cables with excessive bending. We believe that their resolution of this issue is appropriate and minimizes the possibility of cable failure from this cause.

G. Vertical Support.

Observation of support points of cable runs containing long vertical runs was not made due to difficulty in access and consideration of relevant TVA actions taken and available to address the issue. These are: Medium voltage cables are being dc tested. Dry dc testing of low voltage cable is effective for detecting cable damage that might occur at support points which are grounded structures. Class IE cables which are critical to accident effect mitigation and subject to worst high temperature harsh environment have been replaced by thermosetting cables using present support standards.

Low voltage cables can be effectively high potted dry if, in the future, any service failures indicate a sensitivity to vertical support damage under the actual conditions of the BFN installation.

Noted during the tours was the presence of conduit seals at junction boxes intermediate in vertical runs. These seals were obviously supporting the downward portion of the run and thus relieving some of the tension that would otherwise have been passed to the top end of the run.

IV. Pullby Issues

A. General.

Cable pulling concerns have extended to BFN as a result of the discovery of the damage created by parachute cord used in pullbys at Watts Bar Nuclear. Wet dc high pot testing has been accepted as a means of issue resolution if applied to ten worst case cable pullbys. The relative severity ranking of the pullbys at BFN relied on the computation of expected side wall bearing pressures or pulling line tensions during the installation. The calculations, among other factors, involve assumptions of run length (were all available pull points used?), actual coefficient of friction and the geometry of cable positions in the conduit (weight correction factor). In general, the non conservative assumption of using all pull points was made. Factual records do not exist but circumstantial evidence seems to validate this assumption. The friction and weight correction factor assumptions were very conservative.

B. Pull Tension and Side Wall Bearing Pressure.

TVA studies have used several methods for ranking worst case pullbys. The initial selection criteria was described in TVA's reply to NRC of February 5, 1990, Resolution of Cable Installation Concerns. Out of the total population of 1330 safety related conduits, the 120 conduits having the greatest number of pullbys and a length of more than 20 feet were ranked by multiplying length times percent fill and then dividing by the bend radius. The top 15 conduits were inspected primarily for pullbys as they were walked down along with all of the other 55. Detailed calculations were then made of side wall bearing pressure (SWBP) and those conduits were ranked again. The final ranking list of April 25, 1990, is based on side wall bearing pressures that were obtained in these detailed calculations.

Their calculations showed that conduit 3ES4177-IID had extremely high values of both tension and side wall bearing pressure in segment #1. TVA provided us with a print-out of this calculation.

This worst case segment is about 70 feet in length and has 570° of bends. Eleven cables were pulled in originally and consisted of two to twelve conductor #10 and #12 AWG cables having PVC jackets. The first pullby, consisting of a 2/c #12 and a 12/c #10 also with PVC jackets, created the highest tension in the ranking list.

TVA used the extremely conservative factors of 0.75 for friction and 1.4 for weight correction. This created the following:

Pull Tension in Pounds			Side Wall Bearing Pressure		
Allowable*	Forward	Reverse	Allowable	Forward	Reverse
880	471,278	199,114	1000	282,971	119,561

A more realistic set of factors of 0.50 for friction and 1.15 for weight correction yielded the following:

880	4,517	2,334	1000	2,229	1,157

These are much closer to the actual conditions in our opinions. These still may be too conservative if generous quantities of pulling lubricant were used.

* Allowable maximum tension used by TVA today for pullbys is 400 pounds. The allowable maximum tension shown here as 880 pounds is based on using the total circular mils of all the cables multiplied by 0.008 and then reduced by using only 80% of that value to account for unequal sharing of the tension in a multiconductor cable.

C. Friction and Weight Correction Factors.

Actual test data to support the use of a specific coefficient of friction for this set of circumstances is extremely important and hopefully will become available to TVA and the entire industry. The actual values of weight correction factors are somewhat better understood, but could use refinement.

It is unlikely that the lower factors, if used for all of the calculations, would change the ranking to a significant degree.

The lowering of these factors would probably reduce the wide difference in the "forward" and "reverse" results, however.

An example of this wide difference in calculated forces in the two directions is conduit ES 337-I where the forward side wall bearing pressure shows 8,873 pounds and the reverse is 36 pounds. We believe that this does not invalidate the overall ranking method.

It should be pointed out that a change in the coefficient of friction does not make this type of change in a straight pull. Going around successive bends makes a big difference because the tension at each bend goes up by the exponential power of the factor used. This continues to go up at each additional bend.

V. Discussion of Issues

A. Utilization of Pull Points.

The March 1989 Summary Report of Browns Ferry Cable Pulling Concerns states that "cable lubricant (was seen) in more abundance at pullby inspection points than non-pullby points." This was not observed in the April 1990 walkdown inspection and hence the existence, or lack thereof, of pulling lubricant was not seen by us to be an indicator of utilization of a pull point.

We believe that slack in the cables at these points was a more reliable indicator of pull point use. The existence of reasonable slack in almost all of the open boxes indicated that they were actually used as pull points.

There were instances where some cables were rather tightly run across a junction box, but this seemed to have been created by the forces of a later pullby or the result of pulling out slack at some other nearby pullbox.

We did not observe any evidence of cable damage or surface scraping that would probably result from pulling through LB condulets and so conclude that these also were properly used as pull points.

B. Evaluation of Testing Procedure.

A review of the dc testing procedure at BFN indicated that the flooding of the worst case conduits was adequately controlled and that the water was in place throughout the test. Leakage currents were read at the appropriate times so that polarization levels could be determined and recorded. The 240 volt per mil level is considered adequate for these cables while in a wet environment. Lesser test voltage levels tried by TVA have not shown to be effective. We believe that the agreed 240 volt per mil wet test procedure is therefore valid and that the preference for using water shielding has been confirmed.

C. Test Failure.

A wet dc test failure occurred in conduit ES 332-I a few days prior to our arrival. We examined the failure while the cable was still in the junction box. This was accomplished by pulling the cable up a few inches until the failure site was in the box.

The damage consisted of a cut that extended through the hacket and into the insulation of the orange/black and the blue/black conductors. Extensive discussions with electricians and engineers pointed very strongly to the most likely root cause of damage as being workman misjudgment. He seemed to have used a sharp, flat tool to remove the RTV rubber sealant placed in the conduit and around the cable in preparation for a subsequent pullby. The cramped area for work and the tough, resilient nature of the sealant can make removal difficult.

An assessment was made of the total number of seals that might have been similarly exposed to the adverse conditions at the damage location. It was reported that there were less than ten. Consideration was made of the low likelihood of circuit failure even under harsh conditions when damage is most probably "buried" within the insulating material of the sealant and of the potential for introducing new damage when dislodging seals for inspection and/or wet test. As a result we concluded that no further actions were merited or advisable except to reinforce prior actions taken to prevent such damage.

Very obviously the damage was only secondarily caused by the pullbys, not the result of pulling line or cable pressure or abrasion.

At our suggestion the damaged cable was retested after water had been drained from the flooded conduit. Neither the low voltage insulation resistance nor dc high potential tests of the faulted conductors gave a clear indication of a fault. The implication seems clear that the wet dc high potential test is substantially more effective in discovering damage faults in cable than are low or high voltage tests of dry cable.

D. Cable Material Evaluation

Our review of the Project Topical Report, Materials Evaluation and Comparison of Safety Related Cable and Conduit Materials Used at Sequoyah and Browns Ferry Nuclear Plants, June 1988, Rev. 1, established that cable materials at the two stations are very comparable. Two exceptions were that BFN Unit 2 had much more polyethylene insulation and PVC jackets than SQN and that silicone rubber insulation was used at BFN only for pig tails, not in conduit or tray runs. The plant tour made by us supported this finding.

VI. Conclusions

We believe that the successful completion of the Unit 2 evaluation and test program at BFN will demonstrate that the cable system complies very adequately with the required level of reliability. This work includes the wet dc high pot testing of the ten worst case pullby conduit segments; the balance of the run dry dc high pot testing; the cable removal and rework done or scheduled by TVA; the in-place program of failure analysis, reporting and trending; and the updating of TVA standards relative to cable installation procedures.

Because the testing and analysis of the results are not complete at this time, the final conclusion is contingent upon the outcome of this test program.

J.B. Gardner

William A. Thue

Three Appendices attached.

Appendix A

TVA Summary Report Review

After completion of the BFN station tours during the week of April 23, 1990, the March 1989 Summary Report, Evaluation of Browns Ferry Nuclear Plant Cable Installation Concerns was reviewed for compliance with good cable technology as understood by the writers. Five items are notable for the apparent divergence between TVA and other industry thinking.

1. Section 1.3, 1st paragraph on page 2 states that the validity of high potential tests on installed cables is questioned because cables from SQN with defects similar to those discovered by high potential tests were later found "in serviceable condition and could perform their intended function during a design basis accident." The clear implication that there is no interest in discovering whether the handling and installation methods used were inflicting ruptures of insulation up to 90% of their wall thickness is contrary to common sense and would startle and horrify most people looking to utility engineers to protect their safety. Would we expect people to feel safe if they knew their car's brakes were "only" 90% gone just because the brakes were still working?

2. Industry practice vs. published standards or handbooks. Section 2.0, pages 3 through 6, especially bottom of page 5, lean very heavily on the premise that published standards reflect the best and only accessible industry practice. If one is isolated from or independent of the industry and totally dependent upon published documents, this has some - but limited - validity. Specifically, pullbys were occasionally encountered in fossil power plants and handled on a common sense basis. If the ducts were dry and remained so, no failures should or did result. If wet, one found out immediately and remedied the goof quickly and quietly. With the advent of nuclear power plants with more massive cable systems and many design changes during the 10 or more years of design and construction, pullbys apparently became more common. The changing from dry to accident environment made the challenge more critical. With the common 4 to 8 year lag from practice to published standards, it is not surprising that if one relies on published information only he will be far behind many or most other user's practices.

With respect to pulling through LB condulets, it seems absurd to allege (foot of page 5) that lack of published prohibition means there is or was no industry concensus against it! Common sense says that pulling over the 1/16 to 1/8 inch radius bend of the lip of LB condulets complies with no allowable bending radii. No publication known to us advises against pounding stiff cables into condulets with hammers (we have seen this done), but it is not sensible to justify doing so on the basis that no publication, thus concensus, says not to do so.

3. Backfit requirements in standards. The next to last paragraph of Section 2.0, page 6, notes that issues raised by the NRC and dealt with in the post-1970 standards did not have backfit requirements in those standards. Backfit requirements are not an appropriate element of any voluntary standard. No installation instructions for cable (or any other electrical equipment) have ever included backfit requirements in manufacturer's handbooks for obvious reasons. Thus the absence of such in these publications has no relation whatever to the validity or appropriateness of backfit requirements of a regulatory agency.

4. Detection of bend radius deficiencies. Section 5.5.2, page 15, indicates that "degradation of instrument cables due to bend radius deficiencies will be detected as a result of routine instrument calibration and maintenance." Other than visual examination of cables at the instrument location, it is difficult to imagine what degradation mechanism is expected to be uncovered by routine calibration and maintenance. Unless this is clarified, we believe that no credit for such degradation detection is merited.

5. Over-bent MV cables are noted in the last sentence of section 5.5.2, page 15, and dealt with in detail in G-38, R-9 Appendix W, Variance No. 16. Group 2 cables are to be high potential tested at every other outage and will "be reworked if an adverse trend is identified by these tests." It is unclear what "trend" can be expected. Failure rate would seem to be the only significant data to trend. Is this what TVA and NRC intended? The only other data collected in the high potential test is the polarization index (pass/fail) and leakage current. The current values are so small (1 to 3 UA) and roughly recorded as to make accuracy for trending related to bending somewhere in the run a futile endeavor. We believe that the testing, combined with good root cause analysis of the mechanism of any failure encountered, would be far more productive for detecting multiple damage points or degradation than any attempts at trending data that is essentially either go - no go or is very imprecise.

- A2 -

Appendix B

G-38, R-9 Revision Review

A copy of G-38, R-9 furnished to us by TVA during our visit to BFN has been reviewed for comparison with R-8 that was previously studied. Many portions of the text have been extensively and, we believe, properly revised. Over 60 separate revisions were noted.

Specifically, issues of bending radius, pulling lines, pull backs, pullbys, lubrication, jamming, condulets and vertical support have been substantially changed to assure that more conservative practices are used. The changes are in accord with practices verbally described during our plant visit.

We have one suggestion to TVA that we believe could make the specification much more effective in its impact. G-38 now contains much material aimed dominantly at the installer or the QA people monitoring the work. There is also a lot of material that is useful only to engineers and technicians working at desks. Editing to clearly separate or distinguish the material targeting one or the other audience would, we believe, make the specification easier to use and thus more likely to be used as a "reminder reference."

Appendix C

"NEC Changes on Vertical Support of Cable"

The 1990 National Electrical Code was revised in regard to supporting conductors in vertical raceways. Section 300-19 (a) in the 1987 and earlier NEC issues had an exception #1 that said, "If the total vertical riser is less than 25 percent of the spacing specified in Table 300-19 (a), no cable support shall be required." The 1990 Code dropped that exception and hence now requires that only runs in excess of the value in the table (for example, 1/0 copper is 100 feet) be supported. The actual support values are the same in 1990 as the previous Codes, but an editorial change has been made to clarify the range of conductors from the previous "350,001 CM to 500,000 CM", for instance, to "over 350 kcmil through 500 kcmil." No technical data was used to make this rather large change. It was felt that there was no technical data to substantiate the values in the earlier Codes.

We *do not* accept the 1990 Code as a basis for support spacing in nuclear power plants. We understand that the code panel making the changes didn't consider such applications or that the code would be used for this purpose. Since no technical basis is available from the code panel as justification, TVA should provide a technical basis for using the Code for this purpose.