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

ENCLOSURE

SAFETY EVALUATION BY OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE SAFETY PARAMETER DISPLAY SYSTEM

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3

DOCKET NOS. 50-259, 260, AND 296

1.0 BACKGROUND

Item I.D.2, "Plant Safety Parameter Display Console," of Task I.D., "Control Room Design," of the "NRC Action Plan Developed as a Result of the TMI-2 Accident," (NUREG-0660) states that operating reactor licensees and applicants for operating licenses will be required to install a Safety Parameter Display System (SPDS) that will display to operating personnel a minimum set of parameters which define the safety status of the plant. Supplement 1 of NUREG-0737 confirmed and clarified the SPDS requirements in NUREG-0737, indicating that each licensee or applicant is required to submit a safety analysis describing the basis on which the selected parameters are sufficient to assess the safety status of each identified function for a wide range of events including symptoms of severe accidents. Licensees and applicants were also required to submit their specific implementation plans for SPDS.

2.0 INTRODUCTION

Generic Letter (GL) 89-06, "Task Action Plan Item I.D.2 - Safety Parameter Display System - 10 CFR 50.54(f)", along with NUREG-1342, "A Status Report Regarding Industry Implementation of Safety Parameter Display Systems", were issued to all licensees on April 12, 1989. GL-89-06 requested all licensees to furnish one of the following:

1. Certification that the SPDS fully meets the requirements of NUREG-0737, Supplement 1, taking into account the information provided in NUREG-1342.

2. Certification that the SPDS will be modified to fully meet the requirements of NUREG-0737, Supplement 1, taking into account the information provided in NUREG-1342. The implementation schedule for the modifications shall be provided.

3. If a certification cannot be provided, the licensee shall provide a discussion of the reasons for that finding and a discussion of the compensatory action the licensee intends to take or has taken.

NUREG-1342 described methods used by some licensees and applicants to implement SPDS requirements in a manner found acceptable by the staff. NUREG-1342 also described SPDS features that the staff found unacceptable and gives the reasons for finding them unacceptable.

By letter dated July 11, 1989, the Tennessee Valley Authority (TVA, the licensee) committed to certify two months after declaring the SPDS operational in accordance with GL 89-06 (i.e., stating that the operational SPDS meets all of the Supplement 1 to NUREG-0737 requirements). The licensee, by letter dated December 19, 1989, provided a description of the interim Browns Ferry Nuclear (BFN) Plant, Unit 2 Phase 1 SPDS, which was to be functional by restart of Unit 2. In addition, TVA restated their commitment to declare the BFN, Unit 2 SPDS operational during the operating cycle (Cycle 7) following its first refueling outage after restart.

The NRC staff conducted an onsite audit between November 13 and 15, 1990. The purpose of the audit was to assess the status of TVA's interim SPDS (ISPDS) with regard to the eight requirements of Supplement 1 to NUREG-0737.

Furthermore, within the scope of this safety evaluation, the NRC staff examined the following TVA documents: Safety Analysis Report (Reference 1); Human Factors Engineering Plan (Reference 2) for the final, fully operational SPDS; Verification and Validation (V&V) Plan (Reference 3); and the V&V Final Report (Reference 4) for the ISPDS.

3.0 EVALUATION

The staff's safety evaluation of the interim SPDS for BFN, Unit 2 and the final SPDS (full scope) design description for Units 1, 2, and 3 follows. This evaluation is based on the previously identified documentation and the audit conducted in November 1990. It should be noted, that the ISPDS was tailored after the final SPDS design description, with certain departures. TVA plans to convert the ISPDS for Unit 2 into the final, full scope version once the plant process computer has been upgraded. Specific differences between the ISPDS design and the final SPDS are identified below.

3.1 Concise Display of Critical Plant Variables to Control Room Operators

The SPDS function is provided by approximately twenty-seven CRT display pages as a sub-set of the Plant Monitoring System (PMS). The SPDS displays were specifically designed to support the use of the plant's symptom-based Emergency Operating Instructions (EOIs). The SPDS is able to continuously monitor the status of all five of the critical safety functions by monitoring the plant process parameters that are used for EOI entry conditions. All PMS displays contain an SPDS parameter summary status box in the upper right-hand corner. The SPDS status box will normally be green if no EOI entry condition exists. If an EOI entry condition does exist, the status box will turn red and flash. The status box will continue to flash until the operator acknowledges the change in status. If the PMS is displaying a non-SPDS display, the operator can enter into the SPDS by merely touching the SPDS status box. This would display to the operator the SPDS Overview display page. The key characteristic of this display is that it provides the entry conditions status for all four EOIs via status boxes. These EOI status boxes are located on the bottom of all SPDS display pages.

The four EOI status boxes, and the EOIs they represent are:

EOI-1	Reactor Pressure Vessel (RPV) Control
EOI-2	Primary Containment Control - Drywell Parameters
EOI-3	Primary Containment - Suppression Pool Parameters
EOI-4	Radioactive Releases

In addition, the SPDS Overview display page presents a plant mimic, representing the reactor vessel, drywell, suppression pool, and the plant stack. Contained within the mimic are ten bar graphs representing the current value of key plant parameters.

One key parameter associated with the containment conditions critical safety function is containment isolation status. In particular the ISPDS does not include this parameter. However, the licensee intends to include it in the full scope SPDS, but has not decided if it would be part of SPDS-CRT displays or whether the existing containment isolation control panel mimic display would be modified to provide SPDS operators with containment isolation status.

The audit team concluded that the current containment isolation display will satisfy the requirement of Supplement 1 to NUREG-0737 for ISPDS. However, TVA should ensure that this requirement continues to be satisfied in its decision regarding whether to provide containment isolation status as a part of the final SPDS or on a separate display within visual access of the SPDS operator.

3.2 Located Convenient to Control Room Operators

The staff's evaluation of SPDS workspace location included an assessment of how the SPDS displays and controls supported the operator's needs during emergency operations. This included a determination of who was defined by the licensee as an SPDS user.

TVA defined the primary users of the SPDS during emergency conditions as the Assistant Shift Operations Supervisor (ASOS), a licensed senior reactor operator responsible for Unit 2 operations, and the Shift Technical Advisor (STA). One SPDS console is located at the ASOS's desk and another SPDS console is located next to a desk near the control panels. Each console consists of a 19-inch touch screen display and a keyboard. During emergency conditions, the licensee expects that the STA will assist the ASOS in diagnosing plant conditions while the ASOS is using the EOIs. Although only one SPDS console is required to be operational, both of the aforementioned SPDS consoles are expected to be operational. Furthermore, the licensee is considering three additional SPDS consoles (e.g., a dedicated console for the STA).

It is the staff's conclusion that TVA meets this Supplement 1 to NUREG-0737 requirement.

3.3 Continuous Display of Plant Safety Status Information

The NRC audit team evaluated the SPDS to determine if it continuously displayed information about the five safety functions identified in Supplement 1 to NUREG-0737. The SPDS summary status box is displayed on every page of the Plant Monitoring System. This provides a continuous indication of EOI entry conditions.

The audit team concluded that the licensee met this Supplement 1 to NUREG-0737 requirement.

3.4 The SPDS Should Rapidly and Reliably Aid the Control Room Operators in Determining the Safety Status of the Plant

During the audit, the licensee stated that SPDS display static backgrounds are actually created by the SPDS local workstations, while the dynamic data is provided to the displays by the Integrated Computer System (ICS). Display generation is instantaneous between an operator command and the beginning of display generation. Display generation on average is one second. TVA also stated that all trend displays are updated every second and all sensors providing input are real-time. All numerical displays present the data with 0, 1, or 2 decimal places as needed to show current values to three significant figures.

Signal validation for all SPDS data inputs occurs at an interval of every second. SPDS parameters are received from field inputs via the Data Acquisition System (DAS) and PMS. Sensor data fed into the DAS and to the PMS is subjected to a signal validation process.

After the input sensor signal is subjected to signal validation, a quality code is assigned. The signal will be determined to be valid or not valid. Any signal determined invalid will be displayed in blue on the SPDS. Signals determined valid are still assigned a quality code based upon range and alarm levels. These valid signal inputs will be displayed in green, red, magenta, or yellow. At the time of the audit, the instrument loop checks had not yet been performed but are planned before restart of Unit 2.

The operator is alerted to an inoperable SPDS when the display screen clock turns red in color. Software system security is maintained by password protection. The ICS computers are located in a locked and key card access controlled computer room. The licensee's computer support staff maintains administrative control of all passwords. Software changes can only be made at the system operations console. Science Applications International Corporation (SAIC) developed the SPDS for BFN and presently maintains software configuration control.

The audit team identified several concerns regarding the reliability of the BFN, Unit 2 interim SPDS. The concerns included:

- The software configuration management system needs to be formalized.
- Some touch screen displays and keyboard function keys were observed to be unreliable and must be corrected.
- Procedures need to be developed for which terminal locations and personnel can make ISPDS software and database changes.
- Procedures need to be developed to specify how sensor inputs with different scanning rates would be handled.

Because of the above noted examples of SPDS system unreliabilities, the staff concluded that TVA's SPDS does not meet the rapid and reliable requirement of Supplement 1 to NUREG-0737. These SPDS system unreliabilities should be resolved prior to restart of BFN, Unit 2. This issue has been referred to the NRC resident inspectors for follow-up and closure prior to restart.

3.5 The SPDS Shall Be Suitably Isolated From Electrical and Electronic Interference With Equipment and Sensors That Are Used for Safety Systems

SPDS circuit isolation is achieved by the use of qualified class 1E multiplexer equipment manufactured by Computer Products, Inc., physical separation, and fiber optic links.

The staff has determined that the licensee has satisfied this Supplement 1 to NUREG-0737 requirement.

3.6 The SPDS Shall Be Designed to Incorporate Accepted Human Factors Principles

The SPDS design at BFN used human factors guidelines and requirements derived from NUREG-0700, Supplement 1 to NUREG-0737, and NUREG-0800 to derive checklists which served as the basis for a human factors review. The guidelines and checklists used are contained in TVA's Human Factors Engineering Plan. Overall, human factors principles were incorporated into the SPDS design. However, the NRC audit team observed two ISPDS related items which deviated from accepted human factors practices. These items were:

- The sit/stand workstation display for the reactor operator had excessive glare from the control room overhead lights.

- The hood placed on the above workstation obscures part of the ISPDS display (e.g., the ISPDS parameter summary box) when an operator is in a standing position.

TVA should assess these items and initiate appropriate corrective actions. Operator feedback should be considered in this assessment process. These items have been referred to the NRC resident inspectors for follow-up and closure prior to restart of Unit 2.

3.7 The Minimum Information Provided Shall Be Sufficient to Provide Information to Plant Operators About the Five Safety Functions Identified in Supplement 1 to NUREG-0737

The licensee used the following sources to select the necessary parameters for the SPDS: (1) the list of acceptable SPDS parameters for BWRs provided in NUREG-1342, (2) a list of all parameters used as entry conditions to the EOIs, and (3) other similar BWR plant SPDS parameter lists. Subject matter experts and operations personnel then reviewed all lists of proposed parameters for completeness. As a result of these efforts the following list of parameters was selected for the ISPDS:

Reactor Power (Average Power Range Monitors)

Reactor Water Level

Reactor Vessel Pressure

Drywell Temperature

Drywell Pressure

Drywell Hydrogen Concentration

Suppression Pool Water Temperature

Suppression Pool Water Level

Suppression Pool Hydrogen Concentration

Stack Radioactivity Release Rate

Reactor Protection System Scram Signal

The audit team found that the requirement regarding minimum information about the five safety functions identified in Supplement 1 to NUREG-0737 was satisfactory for the interim SPDS; however, this requirement would not be fully satisfied for a fully operational SPDS until the licensee fulfills its commitment to provide additional critical safety function parameters. The licensee has committed to add the following parameters: source range monitors, offgas (pretreatment and post-treatment) effluent monitors, containment radiation monitors, and containment isolation valve status. The licensee is evaluating the addition of containment isolation valve status (i.e., as a part of the SPDS or on a separate control room panel) and drywell oxygen concentration. The results of the evaluation should be submitted to the NRC for review and approval, including justification for the location of containment isolation valve status if not integral to the SPDS, and justification for not providing the drywell oxygen concentration.

3.8 Procedures Should Be Developed and Operators Trained With and Without the SPDS Available

BFN, Unit 2 operators have received a two-hour briefing on the operation of the ISPDS. The licensee stated during discussions that operators will be trained on the use of the ISPDS during both the normal (i.e. without the SPDS) EOI and requalification training programs.

The NRC audit team concluded that TVA would meet the requirement of Supplement 1 to NUREG-0737 related to training and procedures, once TVA satisfies its commitment to have procedures in place and operators trained with and without the SPDS before restart.

3.9 Evaluation of the Verification and Validation Program

A Verification and Validation program is concerned with the process of specification, design, fabrication, testing, and installation associated with an overall system's software, hardware, and operation. For the SPDS, verification is the review of the requirements to see that the right problem is being solved, review of the design to see that it meets the requirements, and testing of system modules to verify that they function properly. Validation includes performance testing of the integrated system to see that it meets all requirements. Validation testing should not only include integrated testing of the hardware and software, but testing of the SPDS as part of the larger system for plant operations which includes the control room, plant procedures, plant operators, and operator training. Supplement 1 to NUREG-0737 does not require that V&V of the SPDS be conducted. However, a V&V program performed by the applicant/licensee during design and implementation of an SPDS will facilitate the NRC review. On the basis of an effective V&V program, the NRC staff can reduce the scope and detail of its technical audit of the SPDS design.

3.9.1 V&V Program Review

The V&V program for the BFN, Unit 2 ISPDS was based on concepts contained in NSAC-39 (Reference 5). The V&V program was conducted by SAIC. SAIC also developed the final SPDS design description used for the ISPDS. However, the SAIC V&V team was made up of members from SAIC who were organizationally and geographically separated. Organizational independence of the two groups was maintained up to the senior vice-president level.

The V&V was performed by SAIC only on the software they had developed. The V&V for the ISPDS was performed in three phases: Requirements Verification, Design Verification, and Validation/Field Installation Verification.

The actual V&V plan was designed to meet the intent of NSAC-39 and the specifics of the TVA Functional Specification. All during the development and implementation phase of the V&V program, reviewers' comments were documented as Discrepancy Reports for additional team review.

The ISPDS requirements verification consisted of four major activities:

- development of an Originating Requirements List
- development of a System Requirements List
- cross reference of Originating Requirements List and the Systems Requirements List
- evaluation of Systems Requirements

Next, the ISPDS Design Verification was conducted consisting of two major tasks:

- correlation of design with system requirements
- evaluation of ISPDS design

Design verification emphasis was placed on software design. Some critical areas of hardware design were also evaluated. However, a detailed evaluation of the hardware was not deemed necessary because the hardware was comprised of all off-the-shelf items.

The final phase of the V&V process was the ISPDS Validation/Field Installation Verification. This phase of the V&V process involved three major activities:

- development of the Validation Test Plan
- review of the developer's test plans and procedures
- performance testing and monitoring of tests

During our audit discussions TVA stated that all field tests had not yet been completed.

Our review of the V&V program and documentation for BFN, Unit 2 was cursory in nature. However, if the ISPDS V&V plan is fully implemented as described during document reviews and audit discussions, the plan should satisfy the recommendations in NUREG-0800, Section 18.2.

3.10 Conclusion

The interim SPDS implemented at Browns Ferry Nuclear Plant, Unit 2, satisfies six of the eight SPDS requirements of Supplement 1 to NUREG-0737. The two Supplement 1 to NUREG-0737 requirements not met were as follows: rapid and reliable, and incorporate accepted human factors principles. The staff is requesting TVA, prior to restart of BFN, Unit 2, to (1) resolve staff concerns regarding ISPDS unreliability (discussed under Section 3.4), (2) correct problems with glare on control room CRTs, and the obscured ISPDS parameter summary status box (discussed under Section 3.6), and (3) satisfy its commitment with respect to training operators with and without the SPDS (discussed under section 3.8). The licensee is also requested to notify the NRC resident inspectors of the results from the corrective actions for items (1) and (2) above. Upon satisfactory resolution of items (1) and (2) and completion of item (3), the ISPDS would be considered by the staff as adequate for use during the first operating cycle following restart of Unit 2, and that TVA should continue with implementation of the final SPDS design.

With regard to the final SPDS design, the licensee must fulfill its commitment to provide additional critical safety function parameters and report to the NRC the results of their evaluation of the containment isolation valve status and drywell oxygen concentration parameters addressed in Section 3.7. When TVA declares the BFN, Unit 2 SPDS operational (i.e., during operating cycle 7 following the next first refueling outage after restart), the staff will issue a supplemental safety evaluation and may conduct a follow-up audit.

Principal Contributors: R. Correia and G. West

Dated: March 6, 1991

References

1. Tennessee Valley Authority, "Browns Ferry Nuclear Plant (BFN) - Notification of Implementation of NUREG-0737 (TMI Action Plan), Item I.D.2.1, Safety Parameter Display System (SPDS), Phase I Installation and Final Design Description," October 22, 1990.

2. Tenneessee Valley Authority, "Human Factors Engineering Plan," January 1990.

3. Tennessee Valley Authority, "Verification and Validation Plan for Tennessee Valley Authority's Browns Ferry Nuclear Plant Interim Safety Parameter Display System," January 5, 1990.

4. Tennessee Valley Authority, "Verification and Validation Final Report for Tennessee Valley Authority's Browns Ferry Nuclear Plant Interim Safety Parameter Display System," Revision 1, September 10, 1990.

5. Science Applications International Corporation, " Verification and Validation for Safety Parameter Display System," NSAC-39, December 1981.