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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING THE SAFETY PARAMETER DISPLAY SYSTEM

WATERFORD STEAM ELECTRIC STATION, UNIT 3

LOUISIANA POWER AND LIGHT COMPANY

DOCKET NO. 50-382

1.0 INTRODUCTION

By letters dated July 8 and 23, 1987, Louisiana Power and Light Company (the licensee) submitted its design for a Safety Parameter Display System (SPDS) for their Waterford Steam Electric Station, Unit 3. This design information was submitted in response to Item I.D.2 of NUREG-0737, Supplement 1.

2.0 DISCUSSION

All holders of operating licenses issued by the Nuclear Regulatory Commission and applicants for an operating license must provide a SPDS in the control room of their plant. The Commission-approved requirements for the SPDS are in Supplement 1 to NUREG-0737, "Clarification of TMI Action Plan Requirements, Requirements for Engineering Response Capability".

Supplement 8 to the Safety Evaluation Report for Waterford 3 (SSER No. 8) contains the results of the staff's evaluation of the licensee's SPDS. At that time, the licensee was an applicant for an operating license. The results from the staff's evaluation are:

> An appropriate commitment to a Human Factors Program was made in the design of the SPDS. However, the staff has identified some characteristics of the displays which appear to conflict with good human factors engineering principles and further information is required.
>
> The SPDS will be suitably isolated from electrical and electronic interference with equipment and sensors that are used in safety systems.
>
> Parameters selected for display are generally adequate to detect critical safety functions for a wide range of events. However, provisions should be made to include a direct indication of containment isolation status in the SPDS parameter set.

Means are provided in the SPDS design to assure that the data displayed are valid. However, the staff is concerned that the means provided may not be effective over a wide range of events and recommends that further data validation be provided.

In addition, the staff performed an on-site postimplementation audit of the SPDS. Consultants from Lawrence Livermore National Laboratories assisted the staff during the September 25-27, 1985 audit of the licensee's SPDS. The results from the audit were transmitted to the licensee by letter dated February 4, 1986 and identified a number of areas where the display system does not comply with regulatory requirements. The staff requested the licensee to provide a program and schedule for resolution of the deficiencies noted in the audit report

The licensee's program to resolve the deficiencies with the display system were submitted by letter dated July 8 and 23, 1987 and described a new design for the display system.

The staff has reviewed the licensee's functional design specification for the Safety Parameter Display System Enhancement Program. From the results of this review, the staff concludes that no serious safety questions exist in the design and implementation may continue. The basis for this conclusion is in the safety evaluation that follows. Also, the conclusion that SPDS implementation may continue does not imply that the SPDS meets or will meet the requirements of Supplement 1 to NUREG-0737. Such confirmation can be made on after a postimplementation audit or when significant information is available for the staff to make such a determination.

3.0 EVALUATIONS

The results from the staff's review of the licensee's parameter selection, data validation techniques, human factors program, adequacy of electrical and electronic isolation devices, and design verification and validation program are presented below.

3.1 SPDS Description

The licensee's SPDS is a part of the Plant Monitoring Computer (PMC). The interface with the control room operator consists of two cathode ray tubes (CRTs) and a keyboard. The PMC processes measured plant data and formats the data for display on the CRTs.

The SPDS consists of two pages of data, one for each CRT. One of the CRTs continuously displays its page of data. This CRT contains data for the Reactivity Control, Reactor Cooling System and Core Heat Removal, Reactor Cooling System Inventory and Pressure Control. This display page also contains a message area for the status of safety systems. The second CRT displays SPDS data on operator demand. The maximum time for accessing the display following an operator's keystroke will be four seconds. The display contains data for Vital Auxiliaries and Containment Status. The data consists of Containment Isolation Status, Radiation Data, Containment Temperature and Pressure, and Containment Combustibles.

Each display contains status indicators (perceptual cues) for the functional data contained on the other display. The status boxes, in conjunction with the other data on the display page, serve to inform operators of the total safety status of the plant from one CRT. Thus, continuous indication of all safety functions is available to operators should one of the two CRTs fail.

3.2 Parameter Selection

Section 4.1f of Supplement 1 to NUREG-0737 states:

> "The minimum information to be provided shall be sufficient to provide information to plant operators about:
>
> (i) Reactivity control;
>
> (ii) Reactor core cooling and heat removal from the primary system;
>
> (iii) Reactor coolant system integrity;
>
> (iv) Radioactivity control; and
>
> (v) Containment conditions."

For review purposes, the staff identifies these five functions as the Critical Safety Functions.

The basis of the licensee's design of the SPDS and the selection of parameters for display is the functions within the Emergency Operating Procedures. The licensee identifies these functions as:

(i) Reactivity control;

(ii) Reactor cooling system inventory control;

(iii) Reactor cooling system pressure control;

(iv) Reactor cooling system and core heat removal;

(v) Containment isolation;

(vi) Containment temperature and pressure control;

(vii) Containment combustible gas control; and

(viii) Vital auxiliaries.

Upon review of these functions, the staff concludes that they exceed the requirements for the Critical Safety Functions identified in NUREG-0737, Supplement 1.

The licensee's functional design specification for the display system contains the results of a comparison between the

(vii) Containment combustible gas control; and

(viii) Vital auxiliaries.

Upon review of these functions, the staff concludes that they exceed the requirements for the Critical Safety Functions identified in NUREG-0737, Supplement 1.

The licensee's functional design specification for the display system contains the results of a comparison between the parameters displayed in the SPDS and the parameters in the Emergency Operation Procedures Safety Function Status Checklist. The result of the comparison indicated that only eleven checklist parameters are not in the SPDS. The licensee's functional specification states the eleven checklist parameters are not in the SPDS so as to reduce display clutter and allow a quicker assessment of the safety function status.

The staff's review also evaluated the parameters selected for each of the Critical Safety Functions. The contents of Table I and of Table II identifies the parameters for each of the licensee's safety functions. The contents of these tables also identify the method of display for a parameter, consisting of numerical value, trend arrow, bar graph, and message. Furthermore, the licensee's functional design description contains illustrations of the display formats for each CRT.

Not all of the data to evaluate fully the critical safety functions resides in the SPDS displays. For example, the value of reactor core water level is on the Qualified Safety Parameter Display System, a Class 1E display that is near the SPDS. The SPDS contains messages on the upper head void and the upper plenum void. Also, the SPDS does not contain the status of several valves that relate to containment isolation. The licensee states that the monitoring of the valves will be through the use of the Emergency Operating Procedures.

During discussions (June 17, 1987) with the licensee's personnel at the plant site, the staff evaluated the control room location of the displays and indicators for the above identified variables not in the SPDS. Some of the variables were in the field of view of the SPDS user. The pertinent information from these displays needed to evaluate safety status was readable from the SPDS work station. However, the location of a few containment isolation valve indicators are behind the user of the SPDS. These indicators are out of the direct field of view of the user. The staff also evaluated the licensee's Emergency Operating Procedures and confirmed the existence of a task list to monitor the status of all containment isolation valves. The SPDS monitors the status of 39 of the 56 valves used in the containment isolation function. The SPDS will display an alarm message if any of the 39 valves monitored fail to close on a containment isolation actuation signal. Based on this data, it is the staff's judgment that the combination of the SPDS, the data within the user's field of view, and the execution of the Emergency Operating Procedures are adequate to evaluate the Critical Safety Functions identified in NUREG-0737, Supplement 1.

3.3 Display Data Validation

The staff reviewed the licensee's display design to determine that means are in the design to assure that the displayed data are valid.

The licensee has described the algorithm used to validate data and to code data. A comparison of the signals from two or more sensors that measures the same process variable determines the validity of the signals. If the difference between the high and the low signal exceeds a comparison band, the signals are "SUSPECT". The comparison bands are twice the quoted instrument string accuracy with allowances for long term drift. The algorithm then processes the suspect points to determine the parameter.

All sensor data is range checked. If the data is outside the allowable range for the sensor, the data is "BAD." When a sensors fails, the operator takes the point out of the computer's scan of sensors. The

operator also inserts a value to the database for the failed sensor. To identify this value, the display uses a label "INSERTED." All sensor data that pass the range check and the comparison check are valid data.

The SPDS uses 33 analog parameters from the plant. Of the 33 analog parameters, 18 are single value parameters and are range checked, but not cross channel compared. The 15 remaining parameters are range checked and cross channel compared.

The display of valid data is in white with no labels. The display of suspect data is in white with an "S" prefix. The display of bad data is with asterisks in the numerical field, but preceded by a "B". Operator inserted data is displayed as bad data.

The staff's review concludes that the display design contains means to validate parameter data. However, in future modifications to the plant, the staff recommends the licensee consider the use of additional sensors and/or analytical methods to improve upon the scope and depth of the validation method.

3.4 Human Factors Program

The staff evaluated the licensee's design for a commitment to a Human Factors Program. The licensee has identified the human factors principles used in the design of the display formats and has submitted copies of the display formats.

The staff's review of the display formats revealed that datum for each Critical Safety Function are in display boxes. Each box's title is a Critical Safety Function. Each box contains the parameters needed to evaluate the function. Labels, numerical values, and units identify the parameters. Also, bars are used as display devices for temperature and level type of process parameters. The datum within the formats are easy to read and uncluttered.

The design of the display formats uses color to code data. Datum that are within normal ranges of operation are in white. Datum in an alarm state are in yellow. This color code is consistent with the existing color code used for alarms throughout the Plant Monitoring Computer. Cyan is the color that codes non-data fields and support information. Dark blue codes background information. The staff notes that red is the conventional color for an alarm state. However, as yellow is the stereotype color for computer based alarms at the plant, it is acceptable.

Each display format contains status indicators to alert operators on a change in status of the safety functions. There are a total of six status indicators, one to represent each of the six Critical Safety Functions. Two status indicators are in the bottom left hand corner of Display 1 to represent the two safety functions in Display 2. Four status indicators are in the bottom left hand corner of Display 2 to represent the four safety functions in Display 1. With this arrangement, operators will remain cognizant of the change in the plant's safety status with a minimum of one display.

In the licensee's design, response time describes the maximum time it takes to update the data from a change at the sensor until the change occurs on the CRT. The response time for the data presented in the SPDS varies from 4.75 seconds to 73 seconds. Most of the thermodynamic data (temperatures, pressures, etc.) have response times between 6 to 7 seconds. Radiation data has the largest response times, 73 seconds. This large response time is due to data processing loads in the computers that transmit and process the data. From the staff's review of the use of the data, it appears that the response times are acceptable to rapidly and reliably evaluate the safety status of the plant.

In order to reduce the number of keystrokes needed to access an SPDS display, the design calls for a hardware change to an existing keyboard. There will be a total of four keys added. Two of the keys (Page CRT1, Page CRT2) are for paging to acquire the display formats. The other two keys (Ack CRT1, Ack CRT2) are for acknowledging an alarmed status indicator. As a result, only one keystroke will be required to either acknowledge a display or page between one of the two displays. The maximum time to page a CRT from one display to the other will be four seconds. These new features of the keyboard and page response time resolve many of the staff's previous concerns on the user interface for the display system.

Based on its review of the licensee's functional design specification for the SPDS Enhancement Program, the staff concludes that the licensee is utilizing human factor principles in the Enhancement Program. The redesign of the SPDS contains features that overcome many of the staff's concerns reported in its previous evaluation in SSER No. 8.

3.5 Electrical and Electronic Isolation

The licensee's redesign of the SPDS did not require new isolation devices. The staff's original review of the isolation devices found the isolation devices acceptable.

3.6 Verification and Validation Program

The text in the licensee's functional specification describes the SPDS Test and Validation Program. The next step in the design is to develop a software specification from the functional specification. The software specification will provide the details of each computer program in the display system. The software specification will be kept current upon changes in the design.

The functional specifications and the software specifications serve as the design basis in testing the display system. The licensee will develop test instructions and test acceptance criteria from these specifications. The tests will evaluate such functions as alarms, trends, data validation, message logic and display, parameter value logic and display, and bar graphs. One of the tests will evaluate the response times of the SPDS displays for a paging request and for step changes in the database. The licensee plans to evaluate and record results from these tests. The staff's review of these activities conclude they should verify the code.

The SPDS Validation Test will use the Waterford 3 simulator. The validation test will use a minimum of three Waterford 3 Emergency Operating Procedures. The procedures selected will exercise all SPDS parameters critical for monitoring the safety status of the plant.

The foundation for validating the availability of critical information parameters will be the task analysis performed during the Detailed Control Room Design Review (DCRDR). A comparison and evaluation will be conducted between the displays and indicators determined during the DCRDR to be relevant in mitigating emergency conditions and the variables displayed on the SPDS. The results from this validation process should confirm that each of the displays and indicators reflects the status of a safety parameter which indicates the accomplishment or maintenance of a plant safety function. Additionally, the licensee will evaluate the ability of the information to be readily perceived and comprehended by control room personnel. The staff's review of the Validation Program concludes that the objectives of the program are acceptable. The results from the Validation Program are subject to staff review during a postimplementation audit of the display system.

The licensee's schedule for an operational SPDS is August 1, 1988. The schedule calls for SPDS hardware installation during the second refueling outage. The schedule for the software calls for the computer program being written and functionally tested by July 1, 1988.

The licensee plans additional validation testing of the SPDS after it is operational. The additional testing will be performed on the simulator. These tests afford operations personnel the opportunity to provide feedback and to ensure that the system is user friendly. The schedule calls for the completion of these tests by December 31, 1988.

The staff's review of the licensee's System Test and Validation Program for the Safety Parameter Display System concludes that the objectives of the test and program are acceptable. As additional guidance in implementing this program, the staff suggests that the licensee also reference NSAC 39.

3.7 Unreviewed Safety Questions

The licensee reviewed the redesigned SPDS against the FSAR and technical specifications. From the results of the review, the licensee finds that SPDS implementation will have no adverse impact upon the safe operation of the plant. The staff finds these results acceptable and consistent with other reviews.

4.0 CONCLUSIONS

The staff has reviewed the licensee's functional design specification for the Safety Parameter Display System Enhancement Program and concludes that the Program, as described in the July 8 and 23, 1987 letters, contains no serious safety questions and that implementation may continue. This conclusion is based on the following:

The variables selected for display are generally adequate to assess critical safety functions;

If implemented as designed, the SPDS will be suitably isolated from plant systems;

The licensee's design provides means to assure that displayed data are valid; and

The licensee commits to conduct a human factors engineering program which will allow reasonable assurance that the information provided will be readily perceived and comprehended by users.

These conclusions on the redesign of the SPDS resolve many of the staff's concerns on the initial design of the system contained in SSER No. 8 and the audit report. The staff also concludes that the schedule for the redesign and implementation of the display is acceptable.

The conclusion that SPDS implementation may continue does not imply that the SPDS meets or will meet the requirements of Supplement 1 to NUREG-0737. Such confirmation can be made only after implementation has been completed.

The licensee is required to inform the Commission, in writing, of any significant changes in the estimated completion schedule as outlined in the safety evaluation above.

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Dated: August 20, 1987

TABLE I

SAFETY PARAMETER DISPLAY SYSTEM

PARAMETERS ON CONTINUOUS CRT

Function and Parameter	Value	Trend Arrow	Bar Graph	Message
Reactivity Control				
1) Log Power	x	x		
2) Reactor Trip				x
3) CEAs Not Inserted				x
Reactor Cooling System and Core Heat Removal				
1) Th (2)	x	x	x	
2) Tc (2)	x	x	x	
3) CET Temp.	x	x		
4) SG Lvl. (2)	x	x	x	
5) SG Pres. (2)	x	x		
6) LPSI Flow (2)	x			x
7) SG1 EFW Flow Low				x
8) SG2 EFW Flow Low				x
9) No RCP Running				
Reactor Cooling System Inventory and Pressure Control				
1) PRZR. Lvl.	x	x	x	
2) PRZR. Pres.	x	x	x	
3) Upper Head Void				x
4) Upper Plenum Void				x
5) Charging Flow	x			
6) HPSI A Unavailable				x
7) HPSI B Unavailable				x
8) CNTMT Sump Level	x	x		
9) RWSP Lvl. Low				x
10) Subcooled Margin	x	x		
Safety Systems				
1) SIAS Actuated				x
2) CIAS Actuated				x
3) CSAS Actuated				x
4) MSIS Actuated				x
5) EFAS Actuated				x
6) RAS Actuated				x

TABLE II

SAFETY PARAMETER DISPLAY SYSTEM

PARAMETERS ON SECOND CRT

Function and Parameter	Value	Trend Arrow	Bar Graph	Message
Containment Isolation				
1) CIAS Actuated				x
2) CNTMT Isolation Incomplete				x*
Radiation Monitoring				
1) Condenser Exhaust	x			
2) Main Steam Line (2)	x			
3) Plant Stack Gas	x			
4) Plant Stack Iodine	x			
5) Containment Area	x			
6) Blowdown	x			
7) CNTMT Atmos. Gas	x			
8) CNTMT Atmos. Particulate	x			
Containment Temperature and Pressure Control				
1) Containment Press.	x	x		
2) Containment Temp.	x	x		
3) CNTMT Spray Flow Low				x
Containment Combustible Gas				
1) H2 Concentration	x	x		
Vital Auxiliaries				
1) 4.16 KV BUS A Deen				x
2) 4.16 KV BUS B Deen				x
3) 4.16 KV BUS A/B Deen				x
4) DC BUS A Deen				x
5) DC BUS B Deen				x
6) DC BUS A/B Deen				x

* Message will identify the panel in which the misaligned valve is located.