U.S. NUCLEAR REGULATORY
COMMISSION
DOCKET 50-410
LICENSE NPF-69

NINE MILE POINT NUCLEAR STATION UNIT 2

UPDATED SAFETY ANALYSIS REPORT

OCTOBER 2016

REVISION 22

Chapter 18

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CHAPTER 18

HUMAN FACTORS ENGINEERING/SAFETY PARAMETER DISPLAY SYSTEM

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HUMAN FACTORS ENGINEERING/SAFETY PARAMETER DISPLAY SYSTEM

18.1 DETAILED CONTROL ROOM DESIGN REVIEW

A control room review program was initiated for the Nine Mile Point Nuclear Station - Unit 2 (Unit 2) in response to NUREG-0737, Supplement 1, and earlier guidance, which required that all licensees and applicants for operating licenses (OL) conduct a detailed control room design review (DCRDR) to identify and correct design deficiencies. NUREG-0700, "Guidelines for Control Room Design Review," issued in September 1981, provided human engineering guidelines to assist each licensee and applicant in performing a detailed control room review. The review program emphasized the determination of the adequacy of information available to the Operator to effectively mitigate emergency conditions. The review program was also designed to correct human factors problems and to improve controls and displays determined to be discrepant from good human factors practices. The DCRDR process, as suggested by NUREG-0700, was divided into four major activities: planning, review, assessment and implementation, and reporting. The human engineering processes developed to address the DCRDR requirements are described in Sections 18.1.1 through 18.1.3.

18.1.1 Reporting Requirements for the DCRDR

NUREG-0737, Supplement 1, required the submittal of a program plan containing the following major elements: 1) a qualified multidisciplinary review team; 2) use of function and task analysis; 3) control room inventory comparison; 4) control room survey; 5) human engineering observation (HEO) assessment; and 6) verification of design improvements.

The program plan, which described how each of the requirements listed above would be (or had been) accomplished, was submitted to the Nuclear Regulatory Commission (NRC) in June 1984.

18.1.2 Summary of Supplement 1 Human Factors Activities to be Performed

The adequacy of the control room was reviewed to determine whether it could provide the system status information, control capabilities, feedback and performance aids necessary for personnel to accomplish their functions and tasks effectively. In addition, characteristics outside the scope of the NRC's DCRDR requirements for the existing control room instrumentation, controls, other equipment and physical arrangements were identified that either add to or detract from Operator performance. The details of the review are included in the DCRDR Final Summary Program Implementation Report which was submitted to the NRC by letter NMP2L-0488 dated September 16, 1985. Six review processes were used to analyze the man/machine interface within the control room: 1) operating experience review (historical document review and Operator survey); 2) system review, function review and task analysis; 3) control room inventory; 4) control room checklist supplement; 5) verification of task performance capabilities; and 6) validation of control room functions.

The first three are foundation processes in which frames of reference and benchmarks for discrepancy identification were established. The last three are investigative processes in which the benchmarks were applied and HEOs identified. Activities performed during these two groups of processes are explained below.

18.1.2.1 Foundation Processes

Industry-wide reviews of Licensee Event Reports (LERs) for similarly designed General Electric-5 (GE-5) plants were analyzed. Since these reports have generic applicability, they were used to identify conditions which affect the probability for Operator error and the safe operation of the generating Station. In addition, operating personnel completed questionnaires and were interviewed to obtain feedback based on previous operating experience.

A control room inventory was conducted on a system-by-system basis to identify all instrumentation, controls, and equipment within the control room. This information was compared to the requirements identified through the analysis of Operator tasks.

A systems review and function allocation review was conducted. Operator task lists were prepared and used during the task analysis and validation of the control room capabilities. These analyses established the information flow and control requirements between the Operator and the control boards.

18.1.2.2 Investigative Processes

Using the foundation processes as a basis, the investigative processes provided the appropriate information necessary to determine the adequacy of the control room from a human engineering perspective. Deficiencies were identified and documented during this part of the review. This step was followed by a verification of task performance capabilities which included: 1) availability and adequacy of the instrumentation and controls, and 2) efficient interface between the Operator and the control board.

Subject to the verification process, a validation of the control room functions was conducted. This procedure determined whether the functions allocated to the operating crew could be accomplished within the structure of the defined emergency operating procedures (EOPs) and the design of the existing control room.

18.1.3 Assessment, Implementation and Scheduling

Upon completion of the supplemental review processes, an examination of the HEOs was conducted by the Human Factors Engineering Review Team. This review served to identify the significance of each of the HEOs, as well as to provide the review team with an opportunity for determining corrective actions where appropriate. A schedule was also developed that will implement the human engineering resolutions.

18.2 SAFETY PARAMETER DISPLAY SYSTEM

18.2.1 Introduction to the Safety Parameter Display System

As a result of the Three Mile Island (TMI) incident in 1979, the NRC issued regulatory requirements regarding the improvement of plant monitoring systems at nuclear power facilities. One requirement dealt with the implementation of a safety parameter display system (SPDS) as described by NUREG-0660, May 1980, and NUREG-0737, November 1980, as supplemented by Generic Letter 82-33, December 17, 1982. Additional information regarding the SPDS was given by NUREG-0800 Section 18.2, November 1984, and NUREG-1342, April 1989.

The purpose of the SPDS is to continuously display information from which plant safety status can be readily and reliably assessed. The principal function of the SPDS is to aid control room personnel during abnormal and emergency conditions in determining the safety status of the plant and in assessing whether abnormal conditions warrant corrective action by Operators to avoid a degraded core.

The NRC conducted a pre-implementation audit of the Unit 2 SPDS on July 17 and 18, 1985. An audit report was issued on September 13, 1985, and Unit 2 replied by letter on November 19, 1985. In the letter, Unit 2 proposed a program for resolving the audit findings; the NRC concluded that this program, as described, if properly executed, should resolve the NRC's findings. The NRC incorporated this letter into the Unit 2 OL as License Condition 2.C(8). As a result, major design changes were made to the SPDS computer software. These included reevaluation and modification of the SPDS parameter set and a complete rewrite of the SPDS calculation and display software. Several new parameter inputs were added to the SPDS from the digital radiation monitoring system (DRMS) and the gaseous effluent monitoring system (GEMS). These systems' displays were deleted from the SPDS. Changes were made to the SPDS computer terminal operator keyboards. The discussion that follows pertains to the modified SPDS.

The SPDS consists of computer generated displays and is a part of the emergency response facility (ERF) integrated system, which is a part of the liquid radwaste (LWS) computer system provided by Honeywell, Inc. Even though the LWS computer performs non-SPDS functions, the Honeywell system software assigns SPDS functions priority over most other system functions. The SPDS displays are available on two LWS computer terminals in the control room, on one LWS computer terminal in the Technical Support Center (TSC), on one LWS computer terminal in the Emergency Operations Facility (EOF), and on the LWS engineer's console in the radwaste control room. One of the two LWS terminals in the control room is used for SPDS displays at all times. Each of these terminals operates independently of the other terminals.

The SPDS display consists of a primary or overview display, the safety function status display, and five secondary displays. There is a separate secondary display for each of the critical safety functions: reactivity control, reactor core cooling and heat removal, reactor coolant system integrity, containment integrity, and radioactivity control. A secondary display may consist of more than one page. A separate function key is provided on the SPDS terminal keyboard for each SPDS display page to "call up" that page. The SPDS display function key layout is the same on all SPDS terminal keyboards, even though the layout for other keys on the keyboard may be different.

The SPDS displays a concise, predetermined set of critical plant variables, defined as SPDS parameters, that are sufficient to provide the minimum information required to assess the critical safety functions. Generally, the analog SPDS parameters are shown as trend plots on the associated safety function displays and color coding is used to indicate the status of the variable. The trend plots are located on the right side of the displays. The left side of the displays is used for nontrended SPDS parameters and supplemental information that may aid in the evaluation of the safety function status. Quantitative information from trended SPDS parameters of other safety functions screen is sometimes displayed on the left side as supplemental information. Information that has automatic range changes indicates the selected range.

At the bottom of each SPDS display, including the overview display, are five blocks, one for each of the five critical safety functions. Each block is color coded to indicate the safety function status. Thus, the five critical safety functions can be evaluated from any SPDS display page. The status of a critical safety function block is derived from the status of the trended parameters associated with that block.

18.2.2 Role of the SPDS

The Unit 2 SPDS helps the control room operating crew make quick and accurate assessments of the plant's safety status during abnormal and emergency conditions, assisting them to decide whether abnormal conditions require corrective action to avoid a degraded core. The SPDS operating procedure requires control room Operators to monitor the SPDS display in the course of performing their assigned monitoring tasks. This integrates the SPDS display into normal operations. The SPDS continuously displays the safety function status of the plant during normal, abnormal, and emergency operations, enhancing the control room Operators' ability to comprehend plant status during stressful conditions, determine rapidly and reliably the safety status of the plant, and intervene in situations that require Operator action.

18.2.3 Scope of the SPDS Analysis

This analysis is limited to those aspects of the SPDS that achieve the principal function of the SPDS. The minimum set of plant variables, the implementing hardware, the data processing algorithms and the Operator training necessary to implement an operational SPDS are the subject of this analysis. This analysis will emphasize the aspects of the SPDS that were modified to resolve NRC audit items from the 1985 audit of the SPDS and documented in the Unit 2 OL Condition 2.C(8). This license condition reads as follows:

"Safety Parameter Display System (SPDS) (Section 18.2, SSERs 3 and 5)

Prior to startup following the first refueling outage, operating licensee shall have operational an SPDS that includes the revisions described in their letter of November 19, 1985. Before declaring the SPDS operational, the operating licensee shall complete testing adequate to ensure that no safety concerns exist regarding the operation of the Nine Mile Point Nuclear Station Unit No. 2 SPDS."

18.2.4 Human Factors Engineering Guidelines

The SPDS is designed within the guidelines of NUREG-0700 particularly as they apply to cathode ray tube (CRT) displays. The human factors manual for future design changes provides the technical basis for the analysis of human factors consideration of the CRT information provided to the control room Operator.

18.2.5 Human Factors Engineering Principles Applied to the SPDS Design

NUREG-0737 Supplement 1 applies specific human factors engineering principles to the SPDS. The following subsection addresses the human factors engineering principles as applied to the Unit 2 SPDS.

18.2.5.1 NUREG-0737, Supplement 1, Section 4.1.a

18.2.5.1.1 Concise Display

The critical set of plant variables is continuously presented on a display on one LWS CRT in the control room as described in Section 18.2.5.1.2. Level II displays are available to provide more detailed information for each of the five safety functions. A second CRT at the same location is also available to provide Level I or Level II displays.

The Unit 2 SPDS was modified to add the critical plant variables necessary to assess radioactivity control to the computer-driven CRT so that the NUREG-0737 Supplement 1 criteria for concise display and same location is met for the radioactivity variables.

The GEMS and DRMS control room displays and recorders no longer function as part of the SPDS. The GEMS and DRMS signals that provide radioactivity critical plant variable information are input to the SPDS. The critical plant variables added to the CRT and the source system of the sensors are:

1. Main stack activity (GEMS)
2. Reactor building vent activity (GEMS)
3. Drywell particulate activity (DRMS)
4. Drywell gaseous activity (DRMS)
5. Offgas activity (DRMS)

Drywell high radiation, isolation valve group position, and main steam line radiation are also included on the radioactivity control screen.

18.2.5.1.2 Critical Plant Variables

The SPDS displays a concise, predetermined set of critical plant variables that are sufficient to provide the minimum information required to assess the critical safety functions. This plant-specific parameter set selection was made by an engineering analysis that considered the following:

1. The BWR Owners Group (BWROG) parameter set described in reports SAI 01381-364LG, "BWR Graphics Display System Dynamic Screening Program," and ALO 1019, "Simulator Evaluation of the BWR Owners Group (BWROG) Graphic Display System."

2. Unit 2 EOP entry conditions pertaining to the reactor and primary containment.

3. The analysis of plant transients and accidents documented in Chapter 15 of the Unit 2 Updated Safety Analysis Report (USAR).

4. The description of compliance with the guidelines of Regulatory Guide (RG) 1.97 as documented in the Unit 2 USAR (Table 7.5-2).

5. NUREG-1342, "A Status Report Regarding Industry Implementation of Safety Parameter Display Systems," dated April 1989.

6. Information obtained from discussion with Unit 2 plant operations and training personnel.

7. The parameter set evaluation was performed by Operations Engineering, Inc. (OEI), under contract to NMPC and submitted as OEI document 8809-1.

With the exception of source range monitor (SRM) count rate, containment isolation valve group position, and safety/relief valve (SRV) position, SPDS parameters are shown as trend plots on the associated safety function displays. In addition to the SPDS parameters, supplemental information is shown on the left side of the SPDS displays or on the safety function status display to aid in evaluating the current status of the plant or of a particular safety function. The same plant variable may be shown as a trended SPDS parameter on one display and as supplemental information, a quantitative value, on another display. A list of SPDS variables and supplemental information variables is given in Table 18.2-1.

18.2.5.1.3 Rapid and Reliable Determination of Safety Status

The Unit 2 SPDS presents correct real-time data to the control room Operator. Perceptual aids (color changes) inform the Operator of valid, questionable and invalid status supported by the LWS computer and the SPDS subsystem software validity checking.

The inputs to the SPDS are from the same sensors that provide information to control room displays, thus providing similar accuracy. The SPDS responds to Operator inputs in approximately 10 sec or less. The time resolution of each trend provides a 5-min history of the trended parameter.

Validity checking is performed by the LWS/ERF (Honeywell) computer system and the SPDS (Honeywell) computer subsystem (see Figure 18.2-1).

The input value from each process sensor is first checked in the process interface unit (PIU) for a hardware failure indication. If such an indication is detected, the value in the LWS (Honeywell) computer is assigned a "no value" code and the Operator is notified of an invalid input by a color change on the display. If there is no hardware failure indication, the input signal is then compared against a high and a low reasonable limit. A sensor reading outside this range is not processed. The value in the Honeywell computer is assigned a "no value" code and the Operator is notified of an invalid input. The sensor input is then monitored for return to reasonability. When the input value is detected as again being reasonable, the Operator is notified and processing of that input is reinitiated.

Contact inputs for isolation valve position are scanned by the PIU to detect a contact change of state and the PIU notifies the Honeywell computer whenever a change occurs. To avoid false indication due to failure of an optical isolator card in the nonsafety-related portions of the valve position indication circuits, the PIU monitors the optical isolator cards for loss of power and for removal from the circuit. Detection of either of these conditions for an isolation valve position signal will cause the associated valve group position to be displayed as "unknown." Loss of power or optical isolator card removal in the safety-related portions of the valve position indication circuits is monitored by the control room annunciators. The Operators will be trained to monitor these annunciators when using the isolation valve group status indication on the SPDS.

In addition to the checks made by the Honeywell system software, including the PIUs, the SPDS subsystem performs independent checks on multichannel inputs by comparing valid values against a predetermined deviation allowance. Where more than two inputs are averaged to calculate the final, displayed value, each input is compared to the average. If any input differs from the average by more than the assigned deviation allowance, the variable is deemed to be "questionable" and the Operator is notified by a color change on the display. For two channel variables, the final value is the average of the two inputs if both are valid. If the difference between the two inputs exceeds the assigned deviation allowance, the variable is deemed to be "questionable" and the Operator is notified by a color change on the display. The deviation allowance check is not used when the maximum input value, rather than the average, is displayed or when a parameter has only a single channel input. For these cases the ERF system software is used to validate the input data.

Therefore, based upon checks performed by SPDS and ERF system software, adequate assurance is provided that the data displayed on the SPDS is valid.

The modified SPDS has eliminated the GEMS and DRMS displays as functional elements of the SPDS. The same instrument loop signals that display on GEMS and DRMS equipment in the control room (previously functional elements of the SPDS) are input to the SPDS subsystem and displayed on the SPDS monitor using real-time data.

Differences between sampling rates have been minimized. Generally, the sample rates ($\geq$1 sec) are more frequent than the update rate (5 sec). The exceptions to this are the temperature parameters which are sampled every 15 sec; this sample rate is suitable for the temperature sensors. These sample rates to update rate ratios minimize the possibility of misleading Operators by variables that appear stable through numerous updates of unsampled variables.

18.2.5.1.4 Aid Control Room Personnel

The Unit 2 SPDS will be operated during normal, abnormal and emergency conditions. Critical plant variables, as noted in Section 18.2.5.1.2, are trended on level two displays that display a 5-min history that is updated every 5 sec. The magnitude of the trend plots is sufficient to differentiate normal, abnormal, and emergency conditions and trends (see Figures 18.2-2 through 18.2-7). The SPDS provides perceptual cues to alert the Operator to abnormal and emergency operating conditions. These include safety function status blocks and trend indicators that change color and other color changes, all based on human factors engineering principles. Reference Section 18.2.6.2.3 for discussion of perceptual aids.

The DRMS and GEMS portion of the original SPDS did not provide the control room Operator with perceptual cues. The modified SPDS added a radioactivity control (level 2 display) screen that provides the required (NUREG-0737 Supplement 1) perceptual cues (reference Section 18.2.6.2.3 and Figure 18.2-7).

18.2.5.2 NUREG-0737, Supplement 1, Section 4.1.b

18.2.5.2.1 Convenient Location

There are two SPDS CRT displays located in the control room on the monitor Operators' console. This is convenient and readily accessible to the control room Operator during performance of assigned tasks. One of the monitors continuously displays the SPDS. This display is unmistakable from other control room displays. The displays meet the intent of readability guidelines of NUREG-0700 Section 6.7.2 CRT displays. The images displayed on the control room SPDS are controlled only by the two control room SPDS keyboards (reference Figure 18.2-8 SPDS Keyboard Main Control Room). The SPDS displays do not interfere with the control room Operators' normal movement, visual access to other control room operating systems, or with displays important for safe operation.

18.2.5.2.2 Continuous Display

One of the two LWS computer terminals in the control room is dedicated to the SPDS mode at all times. This is administratively controlled by the SPDS operating procedure. The addition of the radioactivity control safety function status block at the bottom of each SPDS display page permits all five critical safety functions to be evaluated on a continuous basis. The display for a particular safety function can be selected when detailed information about that safety function is required.

18.2.5.3 NUREG-0737, Supplement 1, Section 4.1.c

18.2.5.3.1 Procedures and Training

The SPDS operating procedure describes safety status assessment when the SPDS is and is not available. User instructions applicable to the Operator are included in this procedure. The control room Operators are required and trained to confirm safety status assessments based on SPDS displays with other control room instrumentation prior to taking action. The Operators will use the same non-SPDS instrumentation and displays to make safety status assessments when the SPDS is unavailable as they use when the SPDS is available. The Operators are trained on the SPDS and the EOP at the same time. The EOP training is done with and without the SPDS so that the Operators are trained to perform safety status assessment with and without the SPDS. The SPDS training includes use of the SPDS during normal and abnormal conditions as well as emergency conditions. No additional control room staff is required during normal and abnormal conditions with or without the SPDS display available.

18.2.5.3.2 Isolation of SPDS from Safety-Related Systems

The SPDS is a nonsafety-related system that is nondivisionally powered. The existing SPDS is a subsystem of the LWS/ERF computer system. The LWS/ERF is a nonsafety-related (nondivisional) computer system. Section 8.3.1.4.1 of the USAR states, "Isolation devices are used at all interfaces between Class 1E divisions and between divisional and nondivisional circuits such as where displays, alarms, and computer circuits connect to Class 1E circuits." This statement is consistent with the Unit 2 commitments stated in USAR Table 1.8 for RG 1.75, Revision 2, "Physical Independence of Electric Systems," and IEEE-384-1974, "IEEE Trial-Use Standard Criteria for Separation of Class 1E Equipment and Criteria."

This modification has added qualified isolation devices where new inputs to the SPDS are added from safety-related (Class 1E/divisional) circuits.

In Supplement 3 to the Safety Evaluation Report (SER), the NRC staff evaluated the Unit 2 SPDS. In their evaluation the NRC staff approved the isolators used to provide the interface (isolation) between Class 1E safety-related instrument signals and the SPDS (i.e., GE optical isolators, Potter and Brumfield MDR relays, and Validyne multiplexers) with the exception of Kaman Industries electronic isolators (part of the DRMS system).

In Supplement 5 to the SER, the NRC staff concluded that the Kaman Industries digital isolator (safety isolation module (SIM)) and the Kaman Industries analog isolator module (AIM) may be used on electrical isolation devices between Class 1E signals and the SPDS. The NRC staff also concluded that this equipment meets the Commission's requirements in NUREG-0737, Supplement 1.

The additional Class 1E safety-related signals added to the modified SPDS are suitably electrically isolated from the SPDS using the NRC-approved GE optical isolators and the Kaman Industries AIMs.

18.2.5.4 NUREG-0737, Supplement 1, Section 4.1.e

18.2.5.4.1 Incorporated Accepted Human Factors Engineering Principles

The modified SPDS design was reviewed by a human factors consultant during the design phase and human factors related recommendations were incorporated into the design. The SPDS was reviewed by a human factors consultant and plant Operators during the man-in-the-loop test.

Human factors reviews made by ARD Corporation (human factors consultant) and plant Operators demonstrate that the characteristics of the SPDS displays and other operational interfaces are sufficient to allow reasonable assurance that the information provided will be readily perceived and comprehended by its users. ARD Corporation performed the human factors review of the original version of SPDS (prefuel load) and has reviewed the modified SPDS.

Specific human factors engineering principles added to the modified SPDS are listed below:

1. "Change the Level II Display Color Coding"

   During the review of the SPDS it was decided to use three colors to indicate parameter conditions: green for normal, yellow for alert, and red for alarm. The graphic generator hardware does not permit three color changes on the history plot. Therefore, it was decided to change the history plot shaded area to half intensity white and to change the trend title background color to green, yellow or red to indicate the parameter condition. This change was acceptable to plant Operators and to the human factors consultant, ARD Associates, and was implemented.

2. "White Numerical Value"

   The revised SPDS screen layout does not permit alarm values to be placed on the left side of the time-history plots. Therefore, the values were placed on the right side of the time-history plots. In addition, the alarm values are colored yellow or red to denote alert or alarm values.

   The initial perception of the limitations of the Honeywell computer graphics generator, combined with schedule restraints associated with the 1990 refueling outage, precluded the use of white dotted lines across the time-history plots to show alarm values. Instead, block-shaped "tic" marks were placed on the left and right time-history plot vertical axes to indicate alarm values. The "tic" marks are intended to be used in conjunction with the colored alarm values mentioned above. This feature will be evaluated by plant Operators prior to declaring the system operational.

3. "Units for the Rate of Change"

   Discussions during the design phase with plant Operators and the human factors consultant concluded that the quantitative rate of change information shown on the SPDS was of no value to the Operators. As a result, the quantitative rate of change information was deleted and replaced by an arrow showing the direction of change. Therefore, rate of change units are not required.

4. "Descriptive Title"

   The description title for each trend on the Level II displays was placed within the border of that trend to increase clarity.

5. "Level I and II Displays"

   To clarify the indication of drywell pressure, two separate scales were used. The zero value is clearly identified on these scales.

18.2.5.4.2 Information Can Be Readily Perceived and Comprehended

The SPDS has incorporated accepted human factors engineering principles using pattern and color coding to aid the Operator to detect and recognize approach to and actual unsafe operating conditions. Red, yellow, green, black, white, cyan and magenta are used in accordance with the guidance of NUREG-0700. Limit marks and values are used for all trended critical plant variables to represent operational limits.

The preliminary analysis of the location of the SPDS relative to the control room Operator evaluating the plant safety status using the EOP is that the location is adequate as it is bounded by normal control room coordination and is supported by combined SPDS and EOP training. The final analysis and evaluation will be performed subsequent to declaring the SPDS operational so as to collect sufficient Operator experience with the SPDS prior to proposing any control room equipment relocations.

18.2.5.5 NUREG-0737, Supplement 1, Section 4.1.f

18.2.5.5.1 Sufficient Information

The information provided to plant Operators by the SPDS is sufficient for the plant Operators to evaluate the following critical safety functions: reactivity control, reactor core cooling and heat removal from the primary system, reactor coolant system integrity, containment integrity, and radioactivity control. A discussion of the SPDS parameter set that provides this information is given in Section 18.2.5.1.2 and the parameter set is listed in Table 18.2-1.

The display format, in terms of the variables shown on each display page, is the same for all modes of operation. However, setpoints that define whether a SPDS parameter is in normal, abnormal, or unsafe/alarm condition may be mode dependent.

The operating mode is shown on the upper left corner of each SPDS display page and is manually entered by the control room Operator using the SPDS terminal keyboard. Selection of the startup or run mode when that mode that is not compatible with the value of several key SPDS parameters is noted by the mode indication being written in yellow and flashing.

18.2.6 SPDS Displays

18.2.6.1 SPDS Display Format

The SPDS is displayed on computer-driven CRT displays. There are two CRT displays in the control room and one is continuously dedicated to the SPDS mode. All displays have safety function status blocks that change color to inform the control room Operator or other observer of the safety status of the critical plant variables. The blocks also prompt the Operator to the appropriate secondary display. Quantitative information about magnitudes and time trends is shown on the secondary displays on 5-min time-history trends. Additionally, other non-SPDS time-history information is available to the Operators in the control room via chart recorders, process computer CRTs and plant computer printouts.

18.2.6.2 Display Techniques

The Unit 2 SPDS uses computer-driven CRT displays to enhance the control room Operators' perception, comprehension and detection of operating conditions that may affect the safety status of Unit 2. The SPDS uses the display enhancement techniques available to CRT displays within the guidelines of NUREG-0700. The CRT display techniques are listed below and the applicability to the Unit 2 SPDS is presented in the subsections of the same title:

1. Graphic Representation of Variables
2. Identification of Displayed Variables
3. Perceptual Aids
4. Display Patterns
5. Status Setpoints

18.2.6.2.1 Graphic Representation of Variables

Trend plots are used to provide graphic representation of analog SPDS parameters on the secondary displays. The trend plots "scroll" horizontally from right to left and the vertical axis of the trend plot represents the magnitude, or height, of the variable. Generally there is a linear relationship between the height of the trend and the magnitude of the variable; however, for the radioactivity control trend curves the relationship is logarithmic. This is compatible with the way radioactivity magnitudes are shown on the corresponding control room radioactivity instrumentation.

Trend plot vertical scales are generally chosen to be the same as the scales of the corresponding control room instrumentation. However, in some cases multiple scales are used for the same trend plot to provide meaningful indication both during normal operation and accident conditions. As requested by plant Operators, the scale changes are made automatically to preclude "off-scale" indication. When a scale change is made, a word in the trend plot title changes to identify which scale is in use, the entire trend plot is redrawn, and the scale numerical markings are changed. Thus, it is clear to the control room Operator which scale is in use. The SPDS variables with multiple scales are identified in Table 18.2.2.

18.2.6.2.2 Identification of Displayed Variables

All SPDS displayed variables are identified by the variable description and the engineering units of the variables. There is no requirement for the user to memorize relationships between display formats or patterns and a specific variable.

18.2.6.2.3 Perceptual Aids

The following subsections present the degree of use of standard CRT display perceptual aids used to enhance Operator perception of the Unit 2 safety function status.

1. Color

   Three colors are used to show the plant safety function status. Green, a neutral color, is used to indicate normal status. The first color change is to yellow, an attention-getting color associated with caution; yellow indicates an abnormal condition. The second color change is to red, an attention-getting color associated with danger; red indicates a serious threat to safety. These colors are consistent with other control room color code applications. The application of color codes is also in accordance with the guidelines of NUREG-0700.

   The first color change to yellow (abnormal condition) indicates the entry point to the EOP for primary containment control or otherwise corresponds to other abnormal condition entry points. All variables do not have two color changes.

   Some variables (e.g., containment oxygen concentration) do not have an EOP entry; however, once the EOP is entered these variables may change significantly due to the transient and/or the corrective actions. The EOPs require close monitoring of these variables and additional corrective action at specific setpoints; these variables will change color to red consistent with the color code above.

Other colors used and applications are listed below:

Black - background color
White - all inputs valid
Cyan - demarcation lines
Magenta - questionable value

2. Symbols and Mimics

Symbols have been avoided. Where symbols are used they are readily distinguishable from each other, are the commonly accepted standard configuration, and have the commonly accepted meaning for all users (e.g., percent - %).

The primary display depicts, in outline, the reactor vessel, the primary containment (drywell, suppression chamber, and suppression pool), the secondary containment, reactor building vent, turbine building, and the main stack. This safety function status display presents a clear depiction of the significance of the critical plant variables.

18.2.6.2.4 Display Patterns

The Unit 2 SPDS does not use displays that rely on pattern recognition of normal and distorted patterns (e.g., chernoff face or circular profile) to determine safety function status.

18.2.6.2.5 Status Setpoints

Setpoint values are used to trigger status indication for analog SPDS parameters and selected supplemental information variables. In general, high limit (HL) and low limit (LL) values are EOP entry conditions and/or normal operating limits specified in the EOPs. These values are triggers for the "abnormal" condition. The high-high limit (HHL) and low-low limit (LLL) values are structural design limits, environmental qualification limits associated with the operability of safety-related equipment under postaccident conditions, extreme conditions that require the executions of contingency actions detailed in the EOPs, or the equivalent. These values are triggers for the "unsafe/alarm" condition.

18.2.7 Verification and Validation of SPDS

An independent verification and validation (V&V) program has been implemented by Eigen Engineering Inc. throughout the design, testing and installation of the modified SPDS. The verification and validation has been performed in accordance with the applicable NSAC-39 guidelines listed below:

1. System Requirements Review
2. Design Review
3. Validation Test
4. Installation Verification
5. Validation Report

The objective of a V&V program is to provide reasonable assurance that the system requirements stated in NUREG-0737, Supplement 1, are satisfied. Based upon the V&V program, it is concluded that the design of SPDS is acceptable since it complies with design criteria as stipulated in NUREG-0800, SRP Section 18.2 SPDS, and with the requirements of License Condition 2.C(8).

The design of the SPDS, as required by NUREG-0800, Section 18.2, complies with the following criteria:

1. The variables displayed by the SPDS are sufficient to provide the minimum information required to assess the status of plant critical safety functions.

2. The SPDS is suitably isolated from electrical and electronic interference with equipment and sensors used in safety systems.

3. Characteristics of the SPDS displays and other operational interfaces are adequate to ensure that the information provided will be readily perceived and comprehended by the operating staff. This conclusion is based upon the consideration of human factors requirements in the design of SPDS.

4. Data validation in the SPDS is adequate.

Generic Letter (GL) 89-06 invokes NUREG-0737 Supplement 1, and NUREG-1342 as design requirements. Since the V&V program addressed NUREG-1342 and since NUREG-0737, Supplement 1, is a requirement of NUREG-0800, it is also concluded that the design of SPDS is consistent with the requirements of GL 89-06.

18.2.8 Testing

Adequate testing shall be completed for the SPDS prior to restart from the first refueling outage that will demonstrate that no safety concerns exist regarding the operation of the Unit 2 SPDS.

A thorough man-in-the-loop testing will be performed prior to restart from the first refueling outage. The man-in-the-loop test will verify that the Honeywell SPDS displays and parameter set provide the necessary safety status information for the plant-specific configuration during normal operation and during postulated abnormal and emergency conditions. These operating scenarios will include events that challenge the Operators beyond Chapter 15 events. This test will also incorporate human factors considerations. The man-in-the-loop test, in conjunction with the "Regulatory Requirements Conformance Evaluation for the Nine Mile Point Unit 2 Safety Parameter Display System," will provide adequate verification that the overall requirements of the SPDS have been satisfied.

An integrated system validation test will be performed for the Honeywell SPDS prior to restart from the first refueling outage. This testing will be in the form of a planned operational computer test following design modifications and the man-in-the-loop test. This testing will ensure that not only will the system function as intended, but also demonstrate that the Operators fully comprehend the display safety status information. Additionally, the testing will aid in the validation of the parameter set as well as the system hardware, software and Operator training. The testing will address aspects of EOPs which include events that challenge the Operators.

18.2.9 Procedures

18.2.9.1 Computer Procedures

Unit 2 will maintain a computer log which documents system failures, their duration, and the equipment that failed. This log will provide a mechanism to evaluate system reliability.

18.2.9.2 Operating Procedures

Operating procedures will ensure that at least one screen of the Honeywell system in the control room will be committed to the SPDS mode at all times.

18.2.9.3 Surveillance Procedures

All SPDS computer points will be identified and included in routine instrument loop surveillance procedures. This task will be initiated prior to restart from the first refueling outage.

Site procedures will be developed that meet the requirement of NUREG-0737 Supplement 1, taking into account information provided in NUREG-1342.

18.2.10 References

1. Nine Mile Point Unit 2 License Condition 2.C(8).

2. NMPC letter NMP2L 0538 to NRC, November 19, 1985.

3. NUREG-1047, NMP2 NRC SSER 3, Section 18.2, SPDS.

4. NUREG-1047, NMP2 NRC SSER 5, Section 18.2, SPDS.

5. NUREG-0696, Functional Criteria for Emergency Response Facilities, Section 5.0.

6. NUREG-0737, Supplement 1, Requirements for Emergency Response Capability, Section 4.0, Generic Letter 82-33.

7. NUREG-0800, Standard Review Plan, Section 18.2, Safety Parameter Display System, Rev. 0.

8. NUREG-1342, A Status Report Regarding Industry Implementation of Safety Parameter Display Systems.

9. NRC letter to NMPC, September 13, 1985, Result of the NRC Audit of Safety Parameter Display System for Nine Mile Point 2.

10. NMPC letter NMP1L 0419 to NRC, July 11, 1989, Response to Generic Letter 89-06, Task Action Plan Item I.D.2-SPDS.

11. NSAC-39, Verification and Validation for SPDS.

12. Regulatory Requirements Conformance Evaluation for the Nine Mile Point Unit 2 Safety Parameter Display System, April 5, 1990; Eigen Engineering Inc.

13. NMP-2 SPDS Parameter Set Evaluation Report (OEI 8809-1), December 1988, Operations Engineering Inc.

14. Basis for the Selection of Information to be Presented on the NMP-2 SPDS (Supplement 1 to OEI 8809-1), October 20, 1989; Operations Engineering Inc.

15. Basis for the Selection of Information to be Presented on the NMP2 SPDS, Supplement 2 to OEI 8809-1 Rev. 0, April 26, 1990; Operations Engineering Inc.

16. Task Action Plan Item I.D.2-SPDS-10CFR50.54(f)-Generic Letter 89-06.

TABLE 18.2-1

SPDS PARAMETER SET

KEY

SPDS Display SFS - Safety Function Status Display
SPDS Display PWR - Reactivity Control Display
SPDS Display CLG - Core Cooling Display
SPDS Display RCS - Coolant System Integrity Display
SPDS Display CNT - Containment Integrity Display
SPDS Display RRC - Radioactivity Control Display

X - SPDS Parameter on this display
+ - Supplemental Information on this display
* - Shown on Safety Function Status Display

Parameter (Critical & Supplemental)	SFS	PWR	CLG	RCS	CNT	RRC
APRM REACTOR POWER	*	X				
BELOW DWSIPL CURVE					+	
CONDENSER VACUUM	*					
CONTAINMENT ISOLATION VALVE GP POS			X	X	X	X
CONTAINMENT HYDROGEN CONC	*				X	
CONTAINMENT OXYGEN CONC	*				X	
DRYWELL GASEOUS ACTIVITY						+
DRYWELL HIGH RADIATION	*					+
DRYWELL PARTICULATE ACTIVITY						+
DRYWELL PRESSURE	*	+		X	X	
DRYWELL TEMPERATURE	*	+	+	+	X	
DW TO SC DIFF PRESSURE					+	
ECCS INJECTION VALVE POSITION			+			
ECCS LINE FLOW RATE			+			
GENERATOR OUTPUT	*					
MAIN STACK ACTIVITY	*					X
MAIN STEAM LINE RADIATION	*					X
NUMBER OF SRV OPEN		X	X	X		
OFFGAS ACTIVITY	*					X
REACTOR BUILDING VENT ACTIVITY	*					X
REACTOR CORE FLOW	*					
REACTOR PRESSURE	*	X	X	X		
REACTOR WATER LEVEL	*	X	X	+		
SRM COUNT RATE		X				
SRM DETECTOR POSITION		+				
SUPPR CHAMBER AIR PRESSURE	*				X	
SUPPR CHAMBER AIR TEMPERATURE	*					
SUPPR CHAMBR PRESS MRGN TO PCPL					+	
SUPPR CHAMBR PRESS MRGN TO PSP					+	
SUPPR POOL LVL MARGIN TO HCLL-INACTIVE					+	
SUPPR POOL LVL MARGIN TO SRVTPLL					+	
SUPPR POOL TEMP MARGIN TO HCTL					+	
SUPPR POOL WATER LEVEL	*				X	
SUPPR POOL WATER TEMPERATURE	*	+			X	

TABLE 18.2-2
SPDS VARIABLES

Variable	Range(s)	SPDS Point	ERF PID / Process Input
APRM Reactor Power	0-125%	SPDSA101	NMP2A273 - AR51 Ch. 1 NMP2A274 - AR31 Ch. 2 NMP2A275 - AR41 Ch. 3 NMP2A276 - AR11 Ch. 4
Below DWSIPL Curve	Yes, No, or Unk	SPDSC117	SPDSA103 - Drywell Temp SPDSA106 - DW Temp Margin to DWSIPL
Condenser Vacuum	0-29.9 in Hg	SPDSA134 (+)	CNMPU100 - 2CNM-PT45A CNMPU101 - 2CNM-PT45B CNMPU102 - 2CNM-PT45C
Containment Isolation Group 1 Position	Yes, No, Unk, or N/A	SPDSC102	MSSZC100 - 2MSS*AOV6A MSSZC101 - 2MSS*AOV6B MSSZC102 - 2MSS*AOV6C MSSZC103 - 2MSS*AOV6D MSSZC104 - 2MSS*AOV7A MSSZC105 - 2MSS*AOV7B MSSZC106 - 2MSS*AOV7C MSSZC107 - 2MSS*AOV7D MSSZC108 - 2MSS*MOV111 MSSZC109 - 2MSS*MOV112 MSSZC110 - 2MSS*MOV208
Containment Isolation Group 2 Position	Yes, No, Unk, or N/A	SPDSC103	RCSZC116 - 2RCS*SOV104 RCSZC117 - 2RCS*SOV105
Containment Isolation Group 3 Position	Yes, No, Unk, or N/A	SPDSC104	NMSZC112 - 2NMS*SOV1A NMSZC113 - 2NMS*SOV1B NMSZC114 - 2NMS*SOV1C NMSZC115 - 2NMS*SOV1D NMSZC116 - 2NMS*SOV1E GSNZC100 - 2GSN*SOV166
Containment Isolation Group 4 Position	Yes, No, Unk, or N/A	SPDSC105	None
Containment Isolation Group 5 Position	Yes, No, Unk, or N/A	SPDSC106	RHSZC100 - 2RHS*MOV67A RHSZC101 - 2RHS*MOV67B RHSZC102 - 2RHS*MOV40A RHSZC103 - 2RHS*MOV40B RHSZC106 - 2RHS*MOV104 RHSZC107 - 2RHS*MOV112 RHSZC108 - 2RHS*MOV113
Containment Isolation Group 6 Position	Yes, No, Unk, or N/A	SPDSC107	WCSZC101 - 2WCS*MOV112

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Containment Isolation Group 7 Position	Yes, No, Unk, or N/A	SPDSC108	WCSZC100 - 2WCS*MOV102
Containment Isolation Group 8 Position	Yes, No, Unk, or N/A	SPDSC109	CCPZC100 - 2CCP*MOV17A CCPZC101 - 2CCP*MOV17B CCPZC102 - 2CCP*MOV94A CCPZC103 - 2CCP*MOV94B CCPZC104 - 2CCP*MOV265 CCPZC105 - 2CCP*MOV273 CCPZC106 - 2CCP*MOV15A CCPZC107 - 2CCP*MOV15B CCPZC108 - 2CCP*MOV16A CCPZC109 - 2CCP*MOV16B CCPZC110 - 2CCP*MOV124 CCPZC111 - 2CCP*MOV122 DFRZC100 - 2DFR*MOV120 DFRZC101 - 2DFR*MOV121 DFRZC102 - 2DFR*MOV139 DFRZC103 - 2DFR*MOV140 DERZC100 - 2DER*MOV120 DERZC101 - 2DER*MOV119 DERZC102 - 2DER*MOV131 DERZC103 - 2DER*MOV130 (SEE NOTE) IASZC100 - 2IAS*SOV184 IASZC101 - 2IAS*SOV164 IASZC102 - 2IAS*SOV165 IASZC103 - 2IAS*SOV166 IASZC104 - 2IAS*SOV180 IASZC107 - 2IAS*SOV185 IASZC108 - 2IAS*SOV167 IASZC109 - 2IAS*SOV168 HCSZC100 - 2HCS*MOV5A HCSZC101 - 2HCS*MOV5B HCSZC102 - 2HCS*MOV6A HCSZC103 - 2HCS*MOV6B HCSZC104 - 2HCS*MOV2A HCSZC105 - 2HCS*MOV2B HCSZC106 - 2HCS*MOV3A HCSZC107 - 2HCS*MOV3B HCSZC108 - 2HCS*MOV4A HCSZC109 - 2HCS*MOV4B HCSZC110 - 2HCS*MOV1A HCSZC111 - 2HCS*MOV1B

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Containment Isolation Group 8 Position (cont'd.)	Yes, No, Unk, or N/A	SPDSC109	CMSZC100 - 2CMS*SOV24A CMSZC101 - 2CMS*SOV24B CMSZC102 - 2CMS*SOV24C CMSZC103 - 2CMS*SOV24D CMSZC104 - 2CMS*SOV60A CMSZC105 - 2CMS*SOV61A CMSZC106 - 2CMS*SOV62B CMSZC107 - 2CMS*SOV61B CMSZC108 - 2CMS*SOV26A CMSZC109 - 2CMS*SOV26B CMSZC110 - 2CMS*SOV26C CMSZC111 - 2CMS*SOV26D CMSZC112 - 2CMS*SOV33A CMSZC113 - 2CMS*SOV33B CMSZC114 - 2CMS*SOV32A CMSZC115 - 2CMS*SOV32B CMSZC116 - 2CMS*SOV62A CMSZC117 - 2CMS*SOV63A CMSZC118 - 2CMS*SOV60B CMSZC119 - 2CMS*SOV63B CMSZC120 - 2CMS*SOV34A CMSZC121 - 2CMS*SOV34B CMSZC122 - 2CMS*SOV35A CMSZC123 - 2CMS*SOV35B LMSZC100 - 2LMS*SOV152 LMSZC101 - 2LMS*SOV153 LMSZC102 - 2LMS*SOV156 LMSZC103 - 2LMS*SOV157 RCSZC100 - 2RCS*SOV65A RCSZC101 - 2RCS*SOV65B RCSZC102 - 2RCS*SOV66A RCSZC103 - 2RCS*SOV66B RCSZC104 - 2RCS*SOV67A RCSZC105 - 2RCS*SOV67B RCSZC106 - 2RCS*SOV68A RCSZC107 - 2RCS*SOV68B RCSZC108 - 2RCS*SOV79A RCSZC109 - 2RCS*SOV79B RCSZC110 - 2RCS*SOV80A RCSZC111 - 2RCS*SOV80B RCSZC112 - 2RCS*SOV81A RCSZC113 - 2RCS*SOV81B RCSZC114 - 2RCS*SOV82A RCSZC115 - 2RCS*SOV82B
Containment Isolation Group 9 Position	Yes, No, Unk, or N/A	SPDSC110	CPSZC100 - 2CPS*AOV106 CPSZC101 - 2CPS*AOV104 CPSZC102 - 2CPS*AOV108

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Containment Isolation Group 9 Position (cont'd.)	Yes, No, Unk, or N/A	SPDSC110	CPSZC103 - 2CPS*AOV110 CPSZC104 - 2CPS*SOV122 CPSZC105 - 2CPS*SOV120 CPSZC106 - 2CPS*AOV107 CPSZC107 - 2CPS*AOV105 CPSZC108 - 2CPS*SOV121 CPSZC109 - 2CPS*SOV119 CPSZC110 - 2CPS*AOV109 CPSZC111 - 2CPS*AOV111 CPSZC112 - 2CPS*SOV132
Containment Isolation Group 10 Position	Yes, No, Unk, or N/A	SPDSC111	ICSZC102 - 2ICS*MOV128 ICSZC103 - 2ICS*MOV121 ICSZC104 - 2ICS*MOV170
Containment Isolation Group 11 Position	Yes, No, Unk, or N/A	SPDSC112	ICSZC100 - 2ICS*MOV148 ICSZC101 - 2ICS*MOV164
Containment Isolation Group 12 Position	Yes, No, Unk, or N/A	SPDSC113	RHSZC112 - 2RHS*MOV24A RHSZC113 - 2RHS*MOV24B RHSZC114 - 2RHS*MOV24C RHSZC117 - 2RHS*MOV25A RHSZC118 - 2RHS*MOV25B RHSZC119 - 2RHS*MOV15A RHSZC120 - 2RHS*MOV15B RHSZC121 - 2RHS*MOV30A RHSZC122 - 2RHS*MOV30B RHSZC123 - 2RHS*MOV27A RHSZC124 - 2RHS*MOV27B RHSZC125 - 2RHS*MOV26A RHSZC126 - 2RHS*MOV26B RHSZC127 - 2RHS*MOV1A RHSZC128 - 2RHS*MOV1B RHSZC129 - 2RHS*MOV1C CSHZC101 - 2CSH*MOV107 CSHZC102 - 2CSH*MOV118 CSHZC104 - 2CSH*MOV105 CSLZC101 - 2CSL*MOV104 CSLZC102 - 2CSL*MOV112 ICSZC105 - 2ICS*MOV122 ICSZC106 - 2ICS*MOV136 ICSZC109 - 2ICS*MOV126 ICSZC110 - 2ICS*MOV143 FWSZC102 - 2FWS*MOV21A FWSZC103 - 2FWS*MOV21B

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Containment Isolation Group 12 Position (cont'd.)	Yes, No, Unk, or N/A	SPDSC113	WCSZC102 - 2WCS*MOV200 SLSZC100 - 2SLS*MOV5A SLSZC101 - 2SLS*MOV5B
Containment Oxygen Concentration	0 - 10%	SPDSA113	CMSOA100 - 2CMS*AIT71A CMSOA101 - 2CMS*AIT71B CMSZC100 - 2CMS*SOV24A CMSZC101 - 2CMS*SOV24B CMSZC102 - 2CMS*SOV24C CMSZC103 - 2CMS*SOV24D CMSZC108 - 2CMS*SOV26A CMSZC109 - 2CMS*SOV26B CMSZC110 - 2CMS*SOV26C CMSZC111 - 2CMS*SOV26D CMSZC112 - 2CMS*SOV33A CMSZC113 - 2CMS*SOV33B CMSZC114 - 2CMS*SOV32A CMSZC115 - 2CMS*SOV32B CMSZC120 - 2CMS*SOV34A CMSZC121 - 2CMS*SOV34B CMSZC122 - 2CMS*SOV35A CMSZC123 - 2CMS*SOV35B
Containment Hydrogen Concentration	0 - 10% (Narrow) 0 - 30% (Wide)	SPDSA114	CMSYA100 - 2CMS*AIT6A CMSYA101 - 2CMS*AIT6B CMSZC100 - 2CMS*SOV24A CMSZC101 - 2CMS*SOV24B CMSZC102 - 2CMS*SOV24C CMSZC103 - 2CMS*SOV24D CMSZC108 - 2CMS*SOV26A CMSZC109 - 2CMS*SOV26B CMSZC110 - 2CMS*SOV26C CMSZC111 - 2CMS*SOV26D CMSZC112 - 2CMS*SOV33A CMSZC113 - 2CMS*SOV33B CMSZC114 - 2CMS*SOV32A CMSZC115 - 2CMS*SOV32B CMSZC120 - 2CMS*SOV34A CMSZC121 - 2CMS*SOV34B CMSZC122 - 2CMS*SOV35A CMSZC123 - 2CMS*SOV35B
Drywell Gaseous Activity	$1.0E^{-7}$ - $1.0E^{-1}$ UCI/CC	SPDSA128 (+)	CMSRA100 - 2CMS*RUZ10A CMSRA101 - 2CMS*RUZ10B
Drywell High Radiation	$1.0E^{+0}$ - $1.0E^{+7}$ R/HR	SPDSA127 (+)	RMSRU100 - 2RMS*RYY1A RMSRU101 - 2RMS*RYY1B RMSRU102 - 2RMS*RYY1C RMSRU103 - 2RMS*RYY1D

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Drywell Particulate Activity	$2.15E^{-9}$ - $1.0E^{-5}$ UCI/CC	SPDSA130 (+)	CMSRA102 - 2CMS*RUZ10A CMSRA103 - 2CMS*RUZ10B
Drywell Pressure	0 to 150 psig -5 to +5 psig	SPDSA111	CMSPA100 - 2CMS*PT2A (Wide) CMSPA101 - 2CMS*PT2B (Wide) CMSPA102 - 2CMS*PT1A (Nar) CMSPA103 - 2CMS*PT1B (Nar)
Drywell Spray Init. Pressure Limit (DWSIPL)	See Process Input Limits	SPDSA104	SPDSA111 - Drywell Pressure SPDSA103 - Drywell Temp
Drywell Temperature	50 - 350°F	SPDSA103	CMSTA108 - 2CMS*TE101 CMSTA109 - 2CMS*TE102 CMSTA110 - 2CMS*TE103 CMSTA111 - 2CMS*TE104 CMSTA112 - 2CMS*TE105 CMSTA113 - 2CMS*TE106 CMSTA117 - 2CMS*TE116 CMSTA118 - 2CMS*TE117 CMSTA119 - 2CMS*TE118 CMSTA120 - 2CMS*TE119 CMSTA121 - 2CMS*TE120 CMSTA122 - 2CMS*TE121
Drywell Temperature Margin to DWSIPL	See Process Input Limits	SPDSA106	SPDSA104 - DWSIPL SPDSA103 - Drywell Temperature
Drywell to Suppression Chamber Differential Pressure	+ or -	SPDSA132	SPDSA111 - Drywell Pressure SPDSA102 - Suppression Chamber Pressure
Generator Output	0 to +1800 MWt	SPDSA133 (+)	SPGQA100 - PMS: SPGQG01
Heat Capacity Level Limit (HCLL) - Inactive	See Process Input Limits	SPDSA120	SPDSA119 - Suppression Pool Temperature Margin to HCTL SPDSA117 - Suppression Pool Level
HPCS Flow	0 - 10,000 gpm	SPDSA140 (+)	CSHFA100 - 2CSH*FT104
HPCS Injection Valve	Yes, No, or Unk	SPDSC122 (+)	CSHZC101 - 2CSH*MOV107
LPCI - A Injection Valve	Yes, No, or Unk	SPDSC118 (+)	RHSZC112 - 2RHS*MOV24A
LPCI - B Injection Valve	Yes, No, or Unk	SPDSC119 (+)	RHSZC113 - 2RHS*MOV24B
LPCI - C Injection Valve	Yes, No, or Unk	SPDSC120 (+)	RHSZC114 - 2RHS*MOV24C
LPCS Injection Valve	Yes, No, or Unk	SPDSC121 (+)	CSLZC101 - 2CSL*MOV104

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
LPCI - A Flow	0 - 10,000 gpm	SPDSA136 (+)	RHSFA104 - 2RHS*FT14A
LPCI - B Flow	0 - 10,000 gpm	SPDSA137 (+)	RHSFA105 - 2RHS*FT14B
LPCI - C Flow	0 - 10,000 gpm	SPDSA138 (+)	RHSFA106 - 2RHS*FT14C
LPCS Flow	0 - 10,000 gpm	SPDSA139 (+)	CSLFA100 - 2CSL*FT126
Main Stack Activity	$1.0E^{+1}$ - $1.0E^{+7}$ UCI/S	SPDSA124	RMSRA104 - 2RMS-REX170
Main Steam Line Radiation	$1.0E^{+0}$ - $1.0E^{+6}$ MR/HR	SPDSA141	MSSRA100 - 2MSS*RT46A MSSRA101 - 2MSS*RT46B MSSRA102 - 2MSS*RT46C MSSRA103 - 2MSS*RT46D
Offgas Activity	$1.0E^{-3}$ - $1.0E^{+2}$ UCI/CC	SPDSA126	OFGRA100 - 2OFG-RE13A OFGRA101 - 2OFG-RE13B
Primary Containment Pressure Limit (PCPL)	See Process Input Limits	SPDSA112	SPDSA117 - Suppression Pool Level SPDSA102 - Suppression Chamber Pressure
Pressure Suppression Pressure (PSP)	See Process Input Limits	SPDSA108	SPDSA117 - Suppression Pool Level SPDSA102 - Suppression Chamber Pressure
Reactor Building Vent Activity	$1.0E^{+1}$ - $1.0E^{+7}$ UCI/S	SPDSA125	RMSRA105 - 2RMS-REX180
Reactor Core Flow	0 - 160,000 KLBS/H	SPDSA135	RCSFA100 - B22-K602A RCSFA101 - B22-K602B
Reactor Pressure	0-1500 psig (Wide) 850-1050 psig (Narrow)	SPDSA109	ISCPA100 - 2ISC*PT6A ISCPA101 - 2ISC*PT6B
Reactor Water Level	-165 to 35 in (Fuel Zone) -5 to 205 in (Wide) 145 to 205 in (Narrow)	SPDSA107	ISCLA102 - 2ISC*LT9C (Wide) ISCLA103 - 2ISC*LT9D (Wide) ISCLA104 - 2ISC*LT13A (FZ) ISCLA105 - 2ISC*LT13B (FZ) ISCLA106 - 2ISC*PDT14A(Narrow) ISCLA107 - 2ISC*PDT14B(Narrow)
SRM Count Rate	10^{-1} to 10^{+6} CPS	SPDSA105	NMS2A100 - C51-N001A NMS2A101 - C51-N001B NMS2A102 - C51-N001C NMS2A103 - C51-N001D
SRM Position	Value, Fail, or Detectors Out	SPDSC101	NMSZC100 - C51-K9A NMSZC101 - C51-K9B NMSZC102 - C51-K9C NMSZC103 - C51-K9D

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
SRV Open (Number of)	1 to 18	SPDSA142	MSSZC111 - 2MSS*PSV131 MSSZC112 - 2MSS*PSV132 MSSZC113 - 2MSS*PSV133 MSSZC114 - 2MSS*PSV134 MSSZC115 - 2MSS*PSV135 MSSZC116 - 2MSS*PSV136 MSSZC117 - 2MSS*PSV137 MSSZC118 - 2MSS*PSV120 MSSZC119 - 2MSS*PSV121 MSSZC120 - 2MSS*PSV122 MSSZC121 - 2MSS*PSV123 MSSZC122 - 2MSS*PSV124 MSSZC123 - 2MSS*PSV125 MSSZC124 - 2MSS*PSV126 MSSZC125 - 2MSS*PSV127 MSSZC126 - 2MSS*PSV128 MSSZC127 - 2MSS*PSV129 MSSZC128 - 2MSS*PSV130
SRV Tail Pipe Level Limit (SRVTPLL)	See Process Input Limits	SPDSA122	SPDSA109 - Reactor Pressure SPDSA117 - Suppression Pool Level
Suppression Chamber Air Pressure	0 - 60 psig	SPDSA102	CMSPA104 - 2CMS*PT7A CMSPA105 - 2CMS*PT7B
Suppression Chamber Air Temperature	50 - 350°F	SPDSA129 (+)	CMSTA114 - 2CMS*TE107 CMSTA115 - 2CMS*TE108 CMSTA116 - 2CMS*TE109 CMSTA123 - 2CMS*TE122 CMSTA124 - 2CMS*TE123 CMSTA125 - 2CMS*TE124
Suppression Chamber Pressure Margin to PCPL	See Process Input Limits	SPDSA116	SPDSA102 - Suppression Chamber Pressure SPDSA112 - Primary Containment Pressure Limit (PCPL)
Suppression Chamber Pressure Margin to PSP	See Process Input Limits	SPDSA110	SPDSA102 - Suppression Chamber Pressure SPDSA108 - Pressure Suppression Pressure (PSP)
Suppression Pool Water Level	192 - 217 Ft (Wide) 198 - 202 Ft (Narrow)	SPDSA117	CMSLA100 - 2CMS*LT9A Wide CMSLA101 - 2CMS*LT9B Wide CMSLA102 - 2CMS*LT11A Narrow CMSLA103 - 2CMS*LT11B Narrow
Suppression Pool Water Level Margin to HCLL - Inactive	See Process Input Limits	SPDSA121	SPDSA117 - Suppression Pool Level SPDSA120 - Heat Capacity Level Limit (HCLL)

TABLE 18.2-2 (Cont'd.)

Variable	Range(s)	SPDS Point	ERF PID / Process Input
Suppression Pool Water Level Margin to SRVTPLL	See Process Input Limits	SPDSA123	SPDSA117 - Suppression Pool Level SPDSA122 - SRV Tail Pipe Level Limit (SRVTPLL)
Suppression Pool Water Temperature	50 - 250°F	SPDSA115	CMSTA100 - 2CMS*TE67A CMSTA101 - 2CMS*TE67B CMSTA102 - 2CMS*TE68A CMSTA103 - 2CMS*TE68B CMSTA104 - 2CMS*TE69A CMSTA105 - 2CMS*TE69B CMSTA106 - 2CMS*TE70A CMSTA107 - 2CMS*TE70B
Suppression Pool Water Temperature Margin to HCTL	See Process Input Limits	SPDSA119	SPDSA115 - Suppression Pool Temperature SPDSA118 - Heat Capacity Temperature Limit (HCTL)

NOTE: Valves 2FPW*SOV218, 219, 220 and 221 are not included on the SPDS because the valves are maintained closed and the FPW lines are capped.

(+) Indicates SEER calculated.