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

SAFETY EVALUATION BY THE
OFFICE OF NUCLEAR REACTOR REGULATION
NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-282 AND 50-306
SAFETY PARAMETER DISPLAY SYSTEM

I. INTRODUCTION

All holders of operating licenses issued by the Nuclear Regulatory Commission (licensees) and applicants for an operating license (OL) must provide a Safety Parameter Display System (SPDS) in the control room of their plant. The Commission approved requirements for the SPDS are defined in Supplement 1 to NUREG-0737.

The purpose of the SPDS is to provide a concise display of critical plant variables to control room operators to aid them in rapidly and reliably determining the safety status of the plant. NUREG-0737, Supplement 1, requires licensees and applicants to prepare a written 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, which include symptoms of severe accidents. Licensees and applicants shall also prepare an Implementation Plan for the SPDS which contains schedules for design, development, installation, and full operation of the SPDS as well as a design Verification and Validation Plan. The Safety Analysis and the Implementation Plan are to be submitted to the NRC for staff review. The results from the staff's review are to be published in a Safety Evaluation Report (SER).

Prompt implementation of the SPDS in operating reactors is a design goal of prime importance. The staff's review of SPDS documentation for operating reactors called for in NUREG-0737, Supplement 1 is designed to avoid delays resulting from the time required for NRC staff review. The NRC staff will not review operating reactor SPDS designs for compliance with the requirements of Supplement 1 of NUREG-0737 prior to implementation unless a pre-implementation review has been specifically requested by licensees. The licensee's Safety Analysis and SPDS Implementation Plan will be reviewed by the NRC staff only to determine if a serious safety question is posed or if the analysis is seriously inadequate. The NRC staff review to accomplish this will be directed at (a) confirming the adequacy of the parameters selected to be displayed to detect critical safety functions, (b) confirming that means are provided to assure that the data displayed are valid, (c) confirming that the licensee has committed to a human factors program to ensure that the displayed information can be readily perceived and comprehended so as not to mislead the operator, and (d) confirming that the SPDS will be suitably isolated from electrical and electronic interference with equipment and sensors that are used in safety systems. If, based on this review, the staff identified a serious safety question or seriously inadequate analysis, the Director of IE or the Director of NRR may require or direct the licensee to cease implementation.

II. SUMMARY

The staff reviewed the SPDS Safety Analysis Report for Prairie Island, Units 1 and 2 and concludes that it is acceptable for the licensee to continue implementing its SPDS Program. The staff finds the parameter selection for Prairie Island's SPDS to be acceptable, but recommends the addition of several parameters to enhance the operators' ability to evaluate the status of safety functions during unique plant accident scenarios. Also, continued implementation of the SPDS is conditional to a confirmatory staff review of the adequacy of the isolation devices between the SPDS and the safety systems. The information needed by the staff to conduct the confirmatory review is defined herein.

III. EVALUATION

Northern States Power Company (NSP) submitted for staff review a Safety Analysis Report and Implementation Plan on the Safety Parameter Display System (SPDS) for the Prairie Island Nuclear Generating Plant, Units 1 and 2 (Ref. 1). This report describes the display system, provides the design bases for the system, discusses parameter selection and display formats, describes the human factors considerations used in the design, and contains a Verification and Validation Plan for the design. The staff's review of the licensee's Safety Analysis Report is presented in the text which follows.

A. SPDS DESCRIPTION

The Prairie Island Safety Parameter Display System is based on a generic design called the Safety Assessment System or SAS. The SAS design was developed by the Ad Hoc Group of the Westinghouse Owners Group Subcommittee on Instrumentation. The NRC staff has been briefed on the generic design (Reference 2) and has witnessed a demonstration of a SAS prototype (Reference 3). To date, the staff has not performed a complete and comprehensive review of the generic design program. The SAS is a set of application software that runs on the emergency response facility computer system. The primary display set for the SPDS function includes 18 displays that are hierarchically organized into one group of top-level displays and two groups of lower-level displays. There are three top-level displays, one for each plant operating mode. These are presented in bargraph format with alerting indicators for critical safety functions. The lower level displays consist of a group of nine trend graphs and a group of six Critical Safety Function (CSF) status trees.

B. PARAMETER SELECTION

Section 4.1f of Supplement 1 to NUREG states that:

"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

(v) Containment conditions."

For review purposes, these five items have been designated as Critical Safety Functions.

In the evaluation of the SPDS variables and in its recommendations, the staff has considered the Westinghouse Owners Group's, "Westinghouse Emergency Response Guidelines (ERGs) Program," which was reviewed and approved by the staff (Reference 4), as a principal technical source of variables important to operational safety. The SPDS variables selected by the licensee and their coordination with the Critical Safety Functions are summarized in Table 1, (grouping made by licensee). Previous variable selection, SPDS design, and SPDS operation were demonstrated for a similar design in an audit review by the staff (Reference 5). While the variables selected do comprise a generally comprehensive list, the staff notes that the status of the following variables were not proposed for the Prairie Island SPDS:

1. Hot Leg Temperature
2. Steam Generator (or steamline) Radiation

3. Containment Isolation
4. Containment Hydrogen Concentration

Hot leg temperature is a key indicator used in the ERGs (Revision 1, "EO-0.1, Attachment A," "Generic Instrumentation," page 3) to determine the viability of natural circulation as a mode of heat removal. The submittal indicates that hot leg temperature is monitored, but is not displayed. Instead, RCS Average Temperature is displayed. The analysis should be expanded to discuss how the hot leg temperature may be rapidly assessed from the SPDS display console.

Steamline (or steam generator) radiation, in conjunction with containment radiation and reactor stack radiation, gives a rapid assessment of radiation status for the most likely radioactive release paths to accomplish the "Radioactivity Control" safety function. For a rapid assessment of Radioactivity Control, the licensee has not demonstrated how radiation in the secondary system (steam generators and steamlines) is monitored by SPDS when the steam generators and/or their steamlines are isolated. The analysis should be expanded to include this discussion.

Containment isolation is an important parameter for use in making a rapid assessment of "Containment Conditions." In particular, a determination that known process pathways through containment have been secured provides significant additional assurance of containment integrity. Containment hydrogen concentration is a key parameter used in the emergency guidelines to monitor combustible gas control and to indicate a compromise of the "Containment Conditions" safety function.

The above variables do, for given scenarios, provide unique input to the determinations of status for their respective Critical Safety Functions, which has not been discussed by the licensee as being satisfied by other variables in the proposed Prairie Island SPDS list. The licensee should address this item by: 1) adding the recommended variables to the Prairie Island SPDS, 2) providing alternate added variables along with justifications that these alternates accomplish the same safety functions for all scenarios, or 3) providing justification that variables currently on the Prairie Island SPDS do in fact accomplish the same safety functions for all scenarios.

Based on this review of the licensee's supporting analyses referencing the Westinghouse Owners Group ERGs, and the staff's observation that the selected variables appear to be consistent with the ERGs, the staff finds the proposed list of key variables to be generally acceptable, with exceptions noted above.

Finally, design flexibility should be provided for possible future expansion of the SPDS. For example, with consideration of the Westinghouse Owners Group ERGs and with possible amendments to the ERGs, other key variables may be identified that are needed to assess the safety status of the Critical Safety Functions.

C. DISPLAY DATA VALIDATION

The staff reviewed the NSP submittal to determine that means are provided in the design to assure that the data displayed are valid. The Prairie Island design provides several checks on data validity depending on the number of sensors available for input. All data undergo a range check. If more than one sensor is available for input, the data points are averaged (assuming they pass the range check). In addition, these data are analysed to determine whether their variance from the average and from each other is reasonable, i.e., for sample size of two, less than 10% variance; for sample size greater than two, variance having a probability of less than 1/(2N).

Based on this use of physical redundancy as well as analytical validation regimes, the staff confirms that means are provided in the SPDS design to assure that the data displayed are valid.

D. HUMAN FACTORS PROGRAM

The staff also evaluated the NSP submittal for a commitment to a Human Factors Program in the development of the SPDS. As evidence of NSP's commitment to a human factors program, the staff noted several aspects of the design process. First, NSP has based its SPDS design on Critical

Safety Functions that are compatible with its Emergency Operating Procedures. This is an important consistency and it has not been overlooked in the NSP design. Secondly, human factors design criteria have been applied in reviewing the design of the SPDS and non-SPDS portions of the SAS. Third, the design was developed by a multidisciplinary team that included human factors engineers, using guidance developed by the NRC (NUREG-0696 and NUREG-0700). The program also included a simulator evaluation at the Indian Point 2 Plant. Based on these observations, the staff confirms that NSP did commit to a human factors program in the design of the Prairie Island SPDS.

E. ELECTRICAL AND ELECTRONIC ISOLATION

Although the licensee has committed to suitable isolation (Reference 1, p. 4.3), adequate information was not provided by the licensee for the staff to confirm that the SPDS will be suitably isolated from electrical and electronic interference and sensors that are used in safety systems. The staff, however, concludes that it is acceptable for the licensee to continue implementing its SPDS Program provided that the SPDS is suitably isolated from electrical and electronic interference with equipment and sensors used for safety systems. However, the licensee shall provide the following information to the NRC for confirmatory review:

a. For each type of device used to accomplish electrical isolation, describe the specific testing performed to demonstrate that the device is acceptable for its application(s). This description should include elementary diagrams where necessary to indicate the test configuration and how the maximum credible faults were applied to the devices.

b. Data to verify that the maximum credible faults applied during the test were the maximum voltage/current to which the device could be exposed, and define how the maximum voltage/current was determined.

c. Data to verify that the maximum credible fault was applied to the output of the device in the transverse mode (between signal and return) and other faults were considered (i.e., open and short circuits).

d. Define the pass/fail acceptance criteria for each type of device.

e. Provide a commitment that the isolation devices comply with the environmental qualifications (10 CFR 50.49) and with the seismic qualifications which were the basis for plant licensing.

f. Provide a description of the measures taken to protect the safety systems from electrical interfence (i.e., Electrostatic Coupling, EMI, Common Mode and Crosstalk) that may be generated by the SPDS.

IV. CONCLUSIONS

The NRC staff reviewed the Prairie Island Safety Analysis to confirm the adequacy of the parameters selected to be displayed to monitor critical safety functions, to confirm that means are provided to assure that the data displayed are valid, to confirm that the licensee has committed to a Human Factors Program to ensure that the displayed information can be readily perceived and comprehended so as not to mislead the operator, and to confirm that the SPDS is suitably isolated.

Based on its review, the staff concludes that no serious safety questions are posed by the proposed SPDS and, therefore, implementation may continue.

This conclusion is based on the following:

1. The variables selected for display are generally adequate to assess critical safety functions, except for the omissions identified in Section III B of this SER.

2. The licensee has stated that the SPDS will be suitably isolated from plant safety systems.

3. The licensee's design provides means to assure that displayed data are valid.

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

The conclusion that SPDS implementation may continue does not imply staff confirmation that the SPDS meets the requirements of Supplement 1 to NUREG-0737. Such confirmation can be made after a post-implementation review or when the staff has otherwise obtained sufficient information.

The continued implementation of the SPDS by the licensee is conditional to a satisfactory confirmatory review by the staff on the design information requested from the licensee in Sections III.B. and III.E. of this Safety Evaluation Report.

V. REFERENCES

1. Letter from D. Musold (NSP) to Director, NRR (NRC) with attachment, dated April 10, 1984.

2. Memorandum for Voss A. Moore (NRC) from Leo Beltracchi (NRC), Subject: Minutes of Safety Assessment System Group/Staff Meeting, December 2, 1981.

3. Memorandum for Voss A. Moore (NRC) from Leo Beltracchi (NRC) and George Lapinsky (NRC), Subject: SAS Demonstration, May 19, 1982.

4. Safety Evaluation of "Emergency Response Guidelines," Generic Letter 83-22, June 8, 1983.

5. "Design Verification Audit Report For The Wolf Creek Safety Parameter Display System (SPDS)," V. A. Moore (HFEB) to B. J. Youngblood (LB1), September 20, 1984.

SPDS CRITICAL SAFETY FUNCTIONS

AND

ASSOCIATED MONITORED AND DISPLAYED PARAMETERS

CRITICAL SAFETY FUNCTION	MONITORED PARAMETER	DISPLAYED PARAMETER
Reactivity Control	(SR, IR, & APR Monitor) Power	(SR, IR, & APR Monitor) Power
	IR Startup Rate	IR Startup Rate
	Reactor Trip Status	Reactor Trip Status
Reactor Core Cooling and Heat Removal From the Primary System	Reactor Vessel Level	Reactor Vessel Level
	Pressurizer Level	Pressurizer Level
	Core Exit Temperature	Core Exit Temperature
	Cold Leg Temperature	Cold Leg Temperature
	Hot Leg Temperature and Cold Leg Temperature	Reactor Coolant Average Temp.
	Reactor Coolant Pump Status	Reactor Coolant Pump Status
	Core Exit Temperature and Reactor Coolant Pressure	Level of Subcooling
	Steam Generator Level	Steam Generator Level
	Steam Generator Pressure	Steam Generator Pressure
	Auxiliary Feedwater Flow	Auxiliary Feedwater Flow
	Steam Generator Steam Flow	Steam Generator Steam Flow
	RHR System Flow	RHR System Flow
	RHR Heat Exchanger Inlet Temp.	RHR Heat Exchanger Inlet Temp.
	RHR Heat Exchanger Oulet Temp.	RHR Heat Exchanger Outlet Temp.
Reactor Coolant System Integrity	Reactor Coolant Loop Pressure and Pressurizer Pressure	Reactor Coolant System Pressure
	Cold Leg Temp. and Hot Leg Temperature	Reactor Coolant Average Temp.
	Cold Leg Temperature	Cold Leg Temperature
	Reactor Vessel Level	Reactor Vessel Level
	Pressurizer Level	Pressurizer Level
	Containment Radiation	Containment Radiation
	Containment Pressure	Containment Pressure
	Containment Sump Level	Containment Sump Level
	Steam Generator Blowdown Rad.	Steam Generator Blowdown Rad.
	Condenser Air Ejector Radiation	Condenser Air Ejector Radiation

Containment Conditions	Containment Pressure	Containment Pressure
	Containment Sump Level	Containment Sump Level
	Containment Radiation	Containment Radiation
Radioactivity Control	Main Stack Radiation	Main Stack Radiation
	Containment Radiation	Containment Radiation
	Steam Generator Blowdown Rad.	Steam Generator Blowdown Rad.
	Condenser Air Ejector Radiation	Condenser Air Ejector Radiation

HFEB SALP INPUT

PRAIRIE ISLAND 1 & 2

SAFETY PARAMETER DISPLAY SYSTEM

(OPERATING PHASE REACTOR)

1. Management involvement and control in assuring quality.

   The Safety Analysis Report contained evidence of prior planning in the design and development of the SPDS. This evidence consisted of the utility's early involvement in organizing a generic response to the NRC requirements for an SPDS.

   Rating: Category 1

2. Approach to resolution of technical issues from a safety standpoint.

   The Safety Analysis Report defined viable and generally sound and thorough approaches to the design of the SPDS.

   Rating: Category 2

3. Responses to NRC initiatives.

   The utility showed good faith and initiative by responding to NRC requirements very early - in some cases, years before other utilities began to respond.

   Rating: Category 1