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February 4, 1985

ARTHUR E. LUNDVALL, JR.
VICE PRESIDENT
SUPPLY

Director of Nuclear Reactor Regulation
Attention: Mr. J. R. Miller, Chief
Operating Reactors Branch #3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Calvert Cliffs Nuclear Power Plant
Units Nos. 1 & 2; Dockets Nos. 50-317 and 50-318
Safety Parameter Display System (SPDS)

Gentlemen:

Your letter dated October 23, 1984, requested additional information concerning the Calvert Cliffs SPDS. Our response to your request is provided in the enclosure to this letter. This new information is being incorporated into the SPDS safety analysis (submitted for staff review on June 6, 1984), a copy of which will be submitted for your record-keeping purposes after it has been finalized.

If you should have any further questions on this subject, please do not hesitate to contact us.

Very truly yours,

A. E. Lundvall

AEL/BSM/vf

Enclosure

cc: D. A. Brune, Esq.
G. F. Trowbridge, Esq.
Mr. D. H. Jaffe, NRC
Mr. T. Foley, NRC

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Enclosure
January 4, 1985

RESPONSE TO NRC 10/23/84
REQUEST FOR ADDITIONAL INFORMATION
CONCERNING THE
CALVERT CLIFFS 1 & 2
SAFETY PARAMETER DISPLAY SYSTEM

Question 1. Isolation Devices

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 when 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 seismic qualifications that were the basis for plant licensing.

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

Response

a. The Data Acquisition System (DAS) provides electrical isolation between the non-safety related SPDS and the plant's safety-related instrumentation systems. The DAS is designed such that a fault associated with any input or output will not affect any other input or output. A block diagram of one channel of the DAS is provided as Attachment 1. The devices within the dotted box comprise the remote I/O cabinets. The inputs are instrument loops and the output is a high speed serial link via fiber-optic cable. The inputs are isolated with various modules selected for the specific signal type. A copy of the test procedure for these isolation modules is provided as Attachment 2 (Remote I/O Equipment Hardware Acceptance Test Procedure for NUS Corp./Baltimore Gas and Electric Company, Calvert Cliffs Data Acquisition System, dated February 2, 1984).

b. Maximum design withstand voltage is 600V sustained and 1250V surge per IEEE Std. 472. Calvert Cliffs electrical circuit and raceway design criteria insures separation between circuits such that input cables are not routed with cables for circuits above 500V rating.

c. Output is via fiber-optic link.

d. Modules were tested to ensure no change of output data and no change in functionality due to the surge test. The test procedure and acceptance critiera are described in Attachment 2 (for example, see sections 9.6, 10.7, and 10.13 for the optically isolated digital input module test process).

e. The isolation devices comply with Calvert Cliffs seismic and environmental qualification program requirements.

f. The design standards applied to the DAS isolation devices will ensure adequate electrical separation between the SPDS and safety-related sytems commensurate with original plant electrical design criteria.

Question 2. **Human Factors Program**

Provide a description of the display system, with emphasis on its human factored design, and the methods and results of a human factors program to ensure that the displayed information can be readily perceived and comprehended so as not to mislead the operator. Color photographs or reproductions of display pages and interface devices may be helpful in supporting the discussion.

Response

The CCNPP SPDS will assist control room personnel in evaluating the safety status of the plant during normal and abnormal operating conditions. Human factors engineering has been incorporated into its design using NUREG-0700 and NUREG-0835 as guideline documents.

The SPDS is a software-based system being implemented as part of the new plant computer which includes one 19-inch plant computer monitor per unit mounted on the control boards (see Attachment 3), one 13-inch SPDS touch screen monitor per unit mounted on the shift supervisor's console, and a 13-inch desk-mounted SPDS monitor in the Technical Support Center. A third plant computer monitor (13-inch) will be located between the Unit 1 and Unit 2 SPDS monitors on the shift supervisor's console.

The SPDS will provide several displays organized under the following Critical Safety Function (CSF) headings:

1. Reactivity
2. RCS Pressure and Inventory
3. Core/RCS Heat Removal
4. Containment Environment
5. Containment Isolation

6. Radioactivity Control
7. Vital Auxiliaries

Under each CSF heading, parameters are displayed which support the CSF in a manner consistent with the new function-oriented emergency operating procedures currently under development. These displays make extensive use of color and coding techniques. Displays are selected by the operator through keyboard action, the CRT cursor, or the touch screen poke points.

Display Formats

Parameter data presented to the operator is grouped under CSF headings in a readily usable format. The following displays are available:

Plant Operating Summary

- Alarm/Indication
- Point Status

Reactivity

- Core Element Assembly (CEA) Matrix Display
- Alarm/Indication
- Point Status

RCS Pressure and Inventory

- RCS P&ID
- RCS Press-Temp Plot
- Alarm/Indication
- Point Status

Core/RCS Heat Removal (two pages)

- Alarm/Indication
- Point Status

Containment Environment

- Alarm/Indication
- Point Status

Containment Isolation

- Alarm/Indication
- Point Status

Radioactivity Control

- Alarm/Indication
- Point Status

A CSF window matrix is located at the top of each display page with the highest priority CSF toward the left. These CSF boxes change color depending on alarm status. Vertical bar graphs are typically located below the CSF matrix for parameter display. The lower portion of the screen is used to display system status information. The display information directly supports its associated CSF. Information is repeated if necessary to minimize requirements for operator memory.

Attachments 4 and 5 provide the **Radioactivity Control** and the **Radioactivity Control Alarm/Indication** display formats.

Display Format Hierachy

Page one of each CSF is accessed by keyboard action using fixed function keys, the CRT cursor or by preselected CRT poke points on the two touch screen displays in the control room Once in a CSF, the user can page down or up, within a CSF, using the "PAG FWD" OR "PAG BWD" keys or CRT poke points.

An alarm/indication box located at the bottom right hand corner is used to access a lower list of alarm descriptors for use in that CSF. The intent of this poke point is to allow quick access to the alarm descriptors while avoiding screen clutter of the first page listing.

Color and Coding Techniques

The following color coding scheme is employed on the CCNPP SPDS:

Green
- a) For CSF Matrix: No decrease in CSF margin; no failure of a safety system detected.
- b) For Individual Parameters: Parameter within its normal range.

Yellow
- a) For CSF Matrix: CSF margin decreased.
- b) For Individual Parameters: Normal range limits exceeded.

Red
- a) For CSF Matrix: Failure of a safety system; the CSF margin is substantially decreased.
- b) For Individual Parameters: Normal range limits substantially exceeded.

White — Bus energized (Electrical Busses Diagram).

Magenta — For CSF only: One or more logic gates in an alarm algorithm for that CSF are invalid due to missing data or failed sensor.

Cyan — Background information.

Color intensity (normal vs low) is used to separate dynamic from static information. Border lines, format lines to separate parameter bars, and titles for parameters are displayed in low intensity cyan. The vertical bar graphs, digital values and system status are displayed in low intensity green and normal intensity yellow and red. Low intensity green, an exception for using normal intensity for dynamic information, provides greater contrast between the yellow and red. Bar graphs, digital values and system status information change color depending on parameter status.

In order to attract the viewer's attention, the CSFs at the top of the display format are in color and reverse video. If one of the alarm algorithms supporting a particular CSF has missing or invalid data, a small magenta square appears in the far right hand corner of the CSF box. This is visible to the viewer and is also noticeable on black and white hard copy. Sensor validity also makes use of the reverse video technique.

Location and Readability

The principal users of the SPDS will be the Shift Supervisor and the Shift Technical Advisor (STA). The Shift Supervisor will be seated directly in front of the 13-inch monitors at a viewing distance of approximately 20 inches. The SPDS displays are not complex in format and occupy less than 30% of the total screen. Alphanumeric characters are displayed using a 5x7 dot matrix.

Audible Alarm

The CCNPP SPDS will alarm the plant annunciator system when sensing a "RED" or "YELLOW" CSF alarm condition. This alarm, as with all control board alarms, will be acknowledged and reset at the control board. The Shift Technical Advisor will be able to cut out the CSF alarm by SPDS keyboard action, thereby allowing additional CSF alarms to annunciate the control board. If the cut-out pushbutton is not depressed, the control board annunciator window will remain in alarm until the SPDS no longer senses the alarm condition.

The purpose of this audible control board alarm is to bring a degraded CSF condition to the attention of the STA.

Question 3. **Data Validation**

Describe the methods used to validate data displayed by the SPDS. Also describe how invalid data is defined to the operator. Please be specific and avoid phrases such as "to the extent possible."

Response

Validation techniques used for the SPDS alarm algorithms and parameter indications are dependent upon the number of sensor inputs available and the type of alarm or indication algorithm employed. Alarm algorithm validation is indicated by coding techniques used on the CSF matrix windows and by inverse video of the invalid line item on the ALARM/INDICATION page. Invalid parameter indication is indicated by reverse video of the digital readouts below the vertical bar graph displays and by inverse video of the invalid line item on the ALARM/INDICATION page.

Alarm Validation

Alarm algorithms make extensive use of sensor channel redundancy for validation. Alarm algorithms which have four redundant sensor inputs use a two-of-four logic to generate an alarm condition. If one or two signals from any of the four channels is invalid or missing, the logic changes to two-of-three or two-of-two, respectively, and a small magenta color box appears next to the associated CSF. If greater than two sensors are invalid or missing, the CSF window will change to a magenta color and the alarm descriptor on the ALARM/ INDICATION page will be displayed in reverse video indicating an invalid alarm algorithm.

Alarm algorithms which have two redundant sensor inputs use a two-of-two logic for generating an alarm condition. If one signal is invalid or missing, the logic changes to one-of-one and a small magenta square will appear next to the associated CSF. If both sensors are invalid or missing the CSF will change to a magenta color and the alarm descriptor on the ALARM/INDICATION page will be displayed in reverse video indicating an invalid alarm algorithm.

Alarm algorithms without redundant sensor inputs will alarm when the sensor exceeds its setpoint. If the signal is invalid or missing, the CSF will change to a magenta color and the alarm descriptor on the ALARM/INDICATION page will be displayed in reverse video indicating an invalid alarm algorithm.

Parameter Indication

Parameter indications which have two or more redundant channels will average the two channels in closest agreement for display information. An instrument loop uncertainty is used to evaluate the validity of the indication. This loop uncertainty is based upon worst case accuracy of components within the loop. If the two closest channels deviate from each other by more than the calculated loop uncertainty, the indication will be flagged invalid. Indications which have only one sensor input are not validated. Invalid parameter information is indicated by reverse video of the digital readouts below the vertical bar graph displays and by reverse video of the invalid line item on the ALARM/INDICATION page.

Question 4. Parameter Selection

Provide further discussion about the rationale of the Calvert Cliffs parameter set in relationship to the Critical Safety Functions. Discussion should include, or refer to, detailed analysis concerning parameter representativeness and responsiveness, and may include a discussion of parameters' relationships to Emergency Procedures.

Response

SPDS parameters were selected to provide the indications required to verify that the safety functions described in CEN-152, "Combustion Engineering Emergency Procedure Guidelines" are being fulfilled. The following paragraphs discuss how the parameters selected to support the CCNPP SPDS Critical Safety Functions differ from the CEN-152 Safety Function Status Check Bases. The CEN-152 Safety Function Status Check Bases are provided for ease of reference as Attachment 6 (Note: CEN-152 does not list indications for radiation control or maintenance of vital auxiliaries. Parameters selected for these displays are explained under discussion of the individual displays).

a. Reactivity Control

All parameter indications recommended by CEN-152 are included. Also included are T_{cold}, boron concentration, boric acid storage tank level, charging pump flow, and ECCS flow. T_{cold} and boron concentration were added because they directly affect reactivity control. Boric acid storage tank level, charging pump flow, and ECCS flow were added because they provide indication of boric acid addition.

b. RCS Pressure and Inventory Control

CEN-152 considers these safety functions separately. However, the CCNPP emergency operating procedures deal with them as a combined function. All parameter indications listed in CEN-152 for RCS pressure control and RCS inventory are provided on the CCNPP SPDS. Also included are the following:

Parameter	Basis
Steam generator pressure	Needed to differentiate between LOCA and steam line break accident.
Core exit thermocouples	Provides indication of core uncovery.
Charging flow, ECCS flow, containment water level, RWT level, VCT level, RAS	Provides indication of available inventory for RCS make up and verification of engineered safety feature functions designed to mitigate LOCA.
Quench tank level, pressure and temperature. Status of pressurizer relief valves, letdown isolation valves, component cooling head tank level, containment radiation monitor, main steam radiation monitor, main vent radiation monitor	Provide for diagnosing accidents involving loss of RCS inventory (possible leakage paths).

c. Containment Isolation

For containment isolation CEN-152 recommends parameter indication for containment pressure, containment area radiation, and secondary system radioactivity. The SPDS utilizes containment area radiation, the main vent radiation monitor, and status of all remotely operated valves which could vent containment atmosphere directly to the environment. Main vent radiation indication facilitates monitoring of any leakage via the containment penetrations (this leakage would be collected by the penetration room ventilation system which discharges into main vent).

Containment pressure indication is included with the containment environment CSF. Steam plant radiation monitor is included with the RCS pressure and inventory control CSF.

d. Radiation Control

The following parameters were selected because they encompass all monitorable release paths to the environment:

Main Vent Radiation Monitor
Condenser Off Gas Radiation Monitor
Main Steam Effluent Radiation Monitor
Liquid Waste Discharge Radiation Monitor
Gaseous Waste Discharge Radiation Monitor

The Containment area radiation monitor was also included in this display to provide information in diagnosing the source of unusual effluent levels in the event of a major release.

e. Vital Auxiliaries

The following parameters were selected to provide indication of the condition of vital support systems which must operate to maintain safety functions.

Parameter	Basis
Header pressure for salt water, service water and component cooling systems	Provides the best available indication that these systems are operating as required.
Voltage indication lights on on vital 4KV, 480V, 125VDC, and 120 VAC electrical busses	These provide indication that engineered safety features instrumentation and equipment have the electrical power required for operation.
Instrument air pressure	Instrument air pressure is not necessary for maintenance of plant safety functions but a

knowledge of insufficient air pressure could significantly change the strategy of dealing with a particular accident.

f. Core and RCS Heat Removal

CEN-152 considers these safety functions separately; however, the CCNPP emergency operating procedures deal with them as a combined function. All parameter indications recommended by CEN-152 for the core heat removal and RCS heat removal functions are included on the CCNPP SPDS with the following exceptions and additions:

Parameter	Basis
T_H (not provided)	In lieu of T_H indication listed in CEN-152, RCS Delta T (T_H-T_C) is provided for both loops (T_H was included in CEN-152 so that the operator could calculate Delta T. For operator convenience the CCNPP SPDS displays Delta T directly).
AFW Flow (added)	Provides verification that the AFW system is acting to maintain or restore steam generator level.
RCS Flow (added)	Provides information for evaluating RCS heat transfer.
SG Pressure (added)	Provides indication of excessive steam demand.
Pressurizer Pressure, Core Exit Thermocouple Temperature (added)	Provides indication of subcooling when RCS forced or natural circulation is not present.
Reactor Vessel Level (added)	Provides indication that reactor vessel contains sufficient coolant to provide adequate heat transfer.

g. Containment Environment

CEN-152 addresses the containment temperature and pressure control function separately from the containment combustible gas control function. However, the CCNPP emergency operating procedures deal with them as a single combined function. All indications listed in CEN-152 for the subject safety functions are provided on the CCNPP SPDS with the following additions:

Parameter	Basis
Containment spray flow, service water flow to containment coolers	Provides indication that containment depressurization systems are operating.
Containment water level	Provides indication of water inventory available for containment spray system.
Containment radiation	Provides indication of radiation levels inside containment as a relative indication of core degradation.

Question 5. Unreviewed Safety Question

Provide a summary of the findings of the Offsite Safety Review Committee meeting of June 21, 1984.

Response

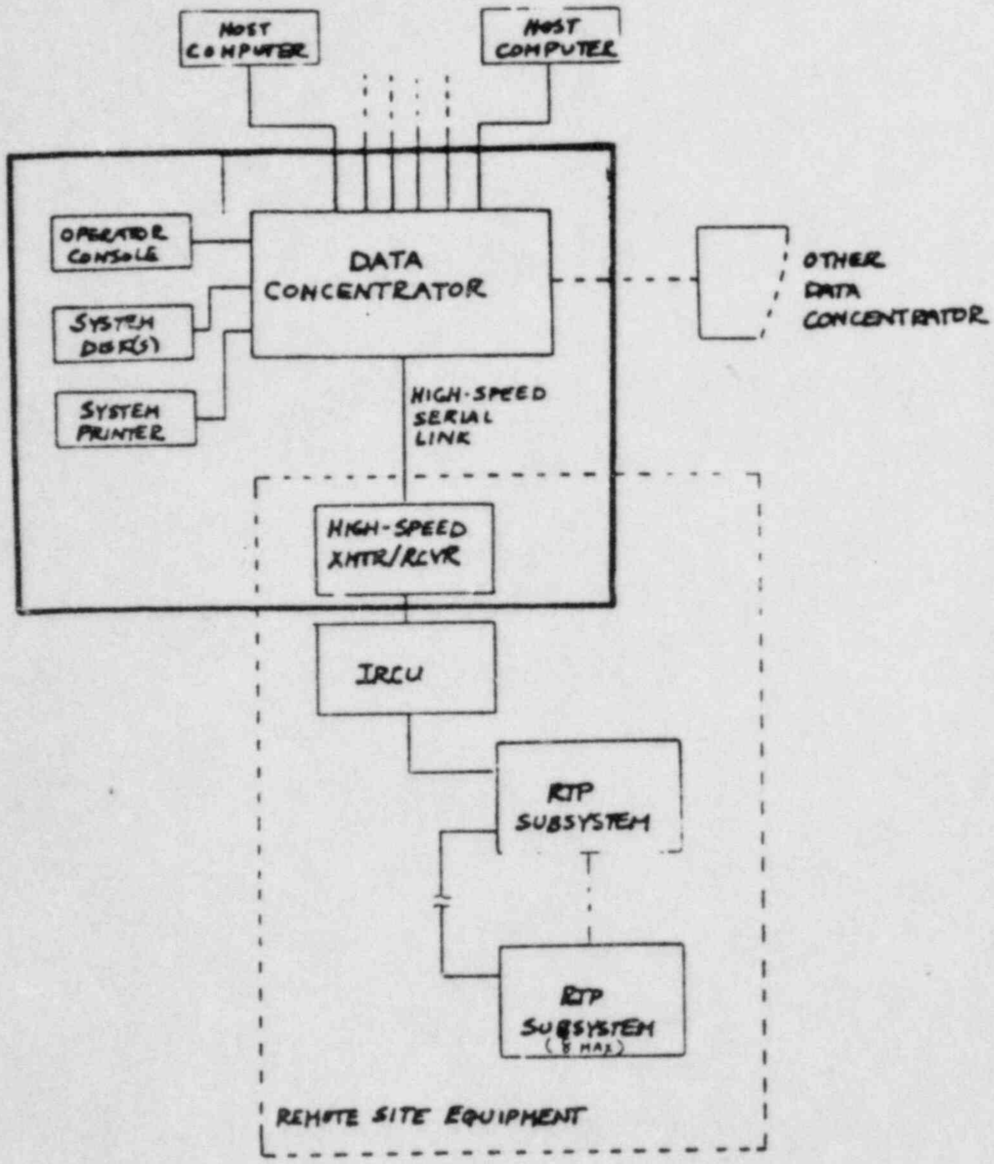
The OSSRC reviewed the SPDS safety analysis on September 21 and December 20, 1984, and has concluded that the SPDS will not pose an undue risk to the public health and safety.

Question 6. Implementation Plan

Provide a tentative schedule for full implementation of the SPDS including hardware, software, operator training, procedures and users manuals.

Response

The CCNPP SPDS implementation schedule was established under an NRC Confirmatory Order dated June 14, 1984. That schedule reflects full implementation of SPDS, including procedure development and training. With regard to the Unit 2 schedule (October 1, 1986), we are contemplating a change to the final implementation date to coincide with the Unit 1 schedule (October 1, 1987).



DATA ACQUISITION SYSTEM (TYPICAL CHANNEL)