ENCLOSURE

SAFETY PARAMETER DISPLAY SYSTEM REPORT

FOR

CALVERT CLIFFS NUCLEAR POWER PLANT

BALTIMORE GAS AND ELECTRIC COMPANY

SEPTEMBER 1988

TABLE OF CONTENTS

	TITLE	PAGE
1.	Introduction	1
2.	General Design Criteria	2
3.	Identification of Critical Safety Functions (CFSs)	3
4.	SPDS Displays	4
5.	Parameter Selections	11
6.	Isolation Devices	17
7.	Human Factors Program	18
8.	Data Validation	22
9.	Safety Analysis	23

Attachments:

1. CEN-152 Safety Function Status Check Bases
2. DAS Block Diagram (one channel)
3. Remote I/O Equipment Hardware Acceptance Test
4. Operator's Console/SPDS CRTs
5. Plant Operating Summary/CSFs Displays

1. Introduction

This report provides a general description and safety analysis for the safety parameter display system (SPDS) installed at the Calvert Cliffs Nuclear Power Plant. Installation of an SPDS was required by Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability, dated December 17, 1982. The function of the SPDS is to provide a concise display of critical plant variables to the control room operators to aid them in rapidly and reliably determining the safety status of the plant during abnormal and emergency conditions and in assessing whether abnormal conditions warrant corrective actions by the operators to avoid a degraded core.

In accordance with Supplement 1 to NUREG-0737 this report identifies the critical safety functions and supporting input parameters that are displayed on the Calvert Cliffs SPDS. Information is also provided regarding the criteria that are or will be applied during the design, fabrication and testing phases. We have determined that installation of the SPDS does not involve an unreviewed safety question or a change to the technical specifications; therefore, a pre-implementation review by the NRC is not required.

On June 6, 1984, we provided a report for the SPDS. Because of updated information, we find it necessary to revise the previously submitted report. This revised report incorporates information contained in our response[1] to NRC's request for additional information and reflects design improvements made to the system during the course of design implementation. Such changes for the most part resulted in additional display parameters and alarms being added to the Critical Safety Functions (CSFs). There were, however, a few deletions from the previous submittal. The steam flow and total feedwater flow were deleted from CSF #3; the graphics display of containment pressure, temperature and radiation versus time were deleted from CSF #4; and the spent fuel pool vent radiation was deleted from CSF #6. Further discussion concerning the basis for parameter selection is included under Section 5. All changes to the SPDS receive appropriate internal review following established design procedures. Under the General Design Criteria Section, we have removed the discussion concerning the need for the operator to shed load from the emergency diesel generator upon a Safety Injection Actuation Signal (SIAS). It was not necessary to shed load or to replace existing batteries because the load requirements of the new computer and Data Acquisition System (DAS) are significantly lower than originally projected. A test report is also provided to document that isolation modules have been successfully subjected to surge withstand capability testing in accordance with IEEE Standard 472. This report contains the SPDS general description and safety analysis in its entirety with revision bars in the right margin to denote changes to the June 6, 1984 report.

---

[1] Letter from A. E. Lundvall, Jr. (BG&E) to J. R. Miller (NRC), dated February 4, 1985, Safety Parameter Display System (SPDS)

2. General Design Criteria

The Calvert Cliffs SPDS is designed as non-Class 1E and non-seismic Category 1.* The software package for the SPDS is included on the new plant computer. The plant computer is powered from an uninterruptible power supply on each unit consisting of a 25 KVA computer inverter, existing plant batteries #12 or #22, and associated battery chargers and 480 volt diesel backed buses. This design ensures that upon loss of offsite power, the SPDS will be available to the operator.

A verification and validation (V&V) program has been implemented by BG&E. The following design review checkpoints are being inserted into the plant computer project schedule to accommodate this effort:

A. Identification and definition of critical safety functions
B. Determination of supporting I/O
C. Formatting of displays
D. Development of alarm algorithms
E. Definition of man machine interface protocol
F. Review of program flowcharts
G. Review of coding
H. Witness of validation testing

All displays are human factored to ensure optimum operator understanding, using NUREG-0700 as the guiding document. Alarms are generated to alert the operator to loss of safety margins or degraded conditions which have the potential for adversely impacting safety margins. Each display page includes a matrix of CSF alarm windows to alert the operator to the status of all CSFs no matter what page he is viewing at a given time. A contact output from the plant computer is an input to the plant annunciator system. The primary user will be the shift supervisor and shift technical advisor. SPDS consoles are provided in the control room and in the technical support center (TSC).

---

* Although the SPDS is non-seismic Category 1, installation of equipment in seismic Category 1 structures, or proximal to any safety related (SR) equipment/ systems are seismically mounted in accordance with established criteria to preclude the possibility of interaction with other SR systems.

3. Identification of Critical Safety Functions (CSFs)

The following critical safety functions are incorporated into the design of the Calvert Cliffs SPDS and are described in further detail in Section 4:

(1) **Reactivity Control**: Provides operator with data required to evaluate power level or shutdown margin of the reactor.

(2) **RCS Pressure and Inventory**: Provides operator with data required to evaluate integrity of RCS and determine adequacy of pressure control function.

(3) **Core/RCS Heat Removal**: Provides operator with data required to determine if core is being adequately cooled.

(4) **Containment Environment**: Provides operator with data required to evaluate condition of containment environment. This data is needed to assess challenges to the containment structure.

(5) **Containment Isolation**: Provides operator with data required to determine if containment is isolated when required.

(6) **Radiation Control**: Provides operator with data required to evaluate releases of radioactivity.

(7) **Vital Auxiliaries**: Provides operator with data required to evaluate status of vital support systems used to prevent or mitigate the consequences of an accident.

4. SPDS Displays

A. CSF #1: Reactivity Control

- Linear power
- Log power
- Start-up rate
- Cold leg temperature
- Boron concentration
- Boric Acid Storage Tank (BAST) level
- Charging pump flow
- High Pressure Safety Injection (HPSI) flow
- Charging source (BAST, Refueling Water Tank [RWT], or Volume Control Tank [VCT]) status
- Control Element Assembly (CEA) mimic
- Status of letdown isolation valves

Red Alarms

- Two or more rods stuck
- Power high after trip
- Anticipated Transient Without Scram (ATWS) condition
- Two or more dropped rods

Yellow Alarms

- Dropped rod
- One stuck rod
- Reactivity addition

B. CSF #2: RCS Pressure & Inventory

- Pressurizer pressure
- Pressurizer level
- Loop subcooled margin
- Steam generator pressure
- Reactor vessel level
- Core exit temperature
- Net charging flow
- HPSI flow
- Low Pressure Safety Injection (LPSI) flow
- Status of pressurizer relief valves
- Containment radiation status
- Steam Generator (SG) blowdown tank radiation status
- Wide range effluent radiation monitor status
- Status of Safety Injection Actuation Signal (SIAS)
- Status of Recirculation Actuation Signal (RAS)
- Component cooling system head tank level status
- Status of Reactor Coolant Pumps (RCPs)
- Containment sump level
- Quench tank level
- Quench tank temperature
- Quench tank pressure
- VCT level
- RWT level
- Letdown flow
- Status of recirculation valves
- Pressurizer pressure versus reactor coolant temperature (Tcold) plot

Red Alarms

- Subcooled margin high
- Emergency Core Cooling System (ECCS) failure
- RAS failure
- Reactor vessel level low
- Reactor Coolant System (RCS) pressure high

Yellow Alarms

- Any pressurizer relief valve open
- Pressurizer level abnormal

C. CSF #3: Core/RCS Heat Removal

- Tcold
- Delta temperature (Thot - Tcold)
- RCS flow
- SG pressure
- SG level
- Auxiliary Feedwater (AFW) flow
- Condensate Storage Tank (CST) level
- Auxiliary Feedwater Actuation Signal (AFAS) status
- AFAS block status
- Steam Generator Isolation Signal (SGIS) status
- Pressurizer pressure
- Loop subcooled margin
- Reactor vessel level
- Core Exit Thermocouples (CET)
- Core subcooled margin
- RCP status
- CET map
- CET trend

Red Alarms

- Tcold high
- CET high
- Loss of primary/secondary heat exchanger
- AFAS failure
- AFAS block failure
- SGIS failure
- SG pressure high high

Yellow Alarms

- Excess cooldown rate
- Subcooled margin low
- Main Steam Line Break (MSLB)/AFAS block
- SG level high
- SG pressure high

D. CSF #4: Containment Environment

- Containment pressure
- Containment temperature
- Containment water level
- Containment radiation
- Containment spray flow
- Total service water to containment coolers
- Containment hydrogen concentration
- Containment Spray Actuation Signal (CSAS) status
- Safety Injection Actuation Signal (SIAS) status
- RAS status

Red Alarms

- Containment cooling inadequate
- CSAS failure
- Main Feedwater (MFW) trip failure
- Containment hydrogen high high

Yellow Alarms

- Containment radiation high
- Containment temperature high
- Containment hydrogen high
- Containment pressure high
- Containment water level high

E. CSF #5: Containment Isolation

- Containment radiation
- Wide range effluent radiation
- Containment purge
- Containment purge sample
- Containment normal sump
- Containment hydrogen purge
- Containment Isolation Signal (CIS) status
- RAS status
- SIAS status

Red Alarms

- CIS failure
- Containment isolation valve failure
- Penetration room vent failure
- RAS and HPSI recirculation to RWT

Yellow Alarms

- Redundant isolation valve open

F. CSF #6: Radiation Control

- Wide range effluent radiation
- Condenser off gas radiation
- Main steam effluent radiation
- Gas waste discharge radiation
- Liquid waste discharge radiation
- Containment radiation
- Control room vent radiation status
- ECCS pump room vent radiation status
- Access control area radiation status
- SG blowdown tank radiation status
- SG blowdown ion exchanger radiation status
- Service water radiation status
- Letdown radiation status
- Component cooling radiation status

Red Alarms

- Condenser off gas radiation high high
- Gas waste discharge radiation high high
- Liquid waste discharge radiation high high
- Main steam effluent radiation high high
- Wide range effluent radiation high high

Yellow Alarms

- Main steam effluent radiation high
- Service water radiation high
- Liquid waste discharge radiation high
- Letdown radiation high
- Gas waste radiation high
- Component cooling radiation high
- Condenser off gas radiation high
- Blowdown tank radiation high
- Wide range effluent radiation monitor high
- Blowdown ion exchanger discharge radiation high

G. CSF #7: Vital Auxiliaries

- Saltwater system header pressure
- Service water system header pressure
- Component cooling water system header pressure
- Instrument air pressure
- Indication of voltage (nominal/low) on 4KV bus 11, 14, (Unit 2: 21, 24)
- Indication of voltage (nominal/low) on 480V bus 11A, 11B, 14A, 14B (Unit 2: 21A, 21B, 24A, 24B)
- Indication of voltage (nominal/low) on 125 VDC bus 11, 12 (Unit 2: 21, 22)
- Indication of voltage (nominal/low) on vital 120 VAC bus 11, 12, 13, 14 (Unit 2: 21, 22, 23, 24)
- Exciter field breaker status
- 500 KV breaker status

Red Alarms

- Loss of two or more 120V vital AC buses
- Loss of both SR 4KV buses
- Loss of all service water
- Loss of all saltwater

Yellow Alarms

- Loss of one 120V vital AC bus
- Loss of one or more 125 VDC buses
- Loss of 11A 480V bus (Unit 2 21A)
- Loss of 11B 480V bus (Unit 2 21B)
- Loss of 14A 480V bus (Unit 2 24A)
- Loss of 14B 480V bus (Unit 2 24B)
- Instrument air pressure low
- One saltwater header pressure low
- Component cooling system pressure low
- One service water header pressure low

5. Parameter Selection

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 1. (Note: CEN-152 does not list indications for Radiation Control or 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 the following:

Parameter	Basis
Cold leg temperature and Boron concentration	Directly affects reactivity control.
BAST level, Charging pump flow and HPSI flow	Provides indication of boric acid addition.
Charging source status	Provides verification that appropriate boric acid source is being used.
Status of letdown isolation valves	Provides information concerning the operability of the downstream Boronometer and Radiation Monitor.

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.

Parameter	Basis
Net charging flow, ECCS flow, Containment sump 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 and letdown isolation valves. Component cooling head tank level, Containment radiation monitor, SG blowdown tank radiation monitor, Wide range effluent radiation monitor	Provide for diagnosing accidents involving loss of RCS inventory (possible leakage paths).
Status of SIAS	Provides verification that appropriate automatic actions associated with pressure and inventory control have occurred.
Status of RCPs	Provides information necessary to determine appropriate spray flow path.
Status of recirculation valves	Provides verification that the Safety Injection Pumps are aligned to the appropriate suction supply.
Pressurizer pressure versus Tcold plot	Provide visual display of operating condition to ensure subcooled margin limits, cooldown/heatup limits, and pump operating limits are followed.

C. 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. With the exception of T_H, 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 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	Provides verification that the AFW system is acting to maintain or restore steam generator level.
RCS flow	Provides information for evaluating RCS heat transfer.
SG pressure	Provides indication of excessive steam demand.
Pressurizer pressure, and CET	Provides indication of subcooling when RCS forced or natural circulation is not present.
Reactor vessel level	Provides indication that reactor vessel contains sufficient coolant to provide adequate heat transfer.
CST level	Provides verification that adequate water inventory is available for RCS heat removal via the SGs.
AFAS status, AFAS block status, and SGIS status	Provides verification that appropriate automatic actions have occurred.
Core subcooled margin, CET map and CET trend	Provides verification that appropriate RCS heat removal exists.
RCP status	Provides information to determine which heat removal method is being used.

D. 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, Total service water 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.
Status of CSAS, SIAS and RAS	Provides verification that appropriate automatic actions have occurred.

E. Containment Isolation

Only one of the three indications recommended by CEN-152 (i.e., Containment radiation) is included. The basis for both the deletions and additions to the SPDS are as follows:

Parameter	Basis
Containment pressure (not provided)	Included with CSF #4, Containment Environment
Secondary system radiation (not provided)	Included with CSF #6, Radiation Control
Wide range effluent radiation	Facilitates monitoring of any leakage via the containment penetrations (this leakage would be collected by the penetration room ventilation system which discharges into the plant vent).
Status of remotely operated purge valves	Provides indication of pathways venting directly to environment.
Status of CIS, RAS and SIAS	Provides verification that appropriate automatic actions have occurred.

F. Radiation Control

The following parameters were selected to provide radiation indication.

Parameter	Basis
Wide range effluent radiation Condenser off gas radiation Main steam effluent radiation Liquid waste discharge radiation Gaseous waste discharge radiation	Encompass all monitorable release paths to the environment.
Containment radiation	Provides information for diagnosing the source of unusual effluent levels in the event of a major release.
Status of Control room vent radiation, SG blowdown tank radiation, SG blowdown ion exchanger radiation	Provides verification that appropriate automatic actions have occurred.
Status of ECCS pump room vent radiation and Access control area radiation	Provides information concerning plant accessibility.
Service water radiation status	Provides an indication of spent fuel pool leakage to the service water system.
Letdown radiation status	Provides for an on-line monitor of fuel failure.
Component cooling radiation status	Provides an indication of shutdown cooling heat exchanger leakage to the component cooling system.

G. 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.

Parameter	Basis
Voltage indication lights 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 features but a knowledge of insufficient air pressure could significantly change the strategy of dealing with a particular accident.
Exciter field breaker status	Provides indication that the breaker has automatically opened following a trip.
500 KV breaker status	Provides information concerning the availability of offsite power.

6. Isolation Devices

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 2. 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 was previously provided. The report documenting test results on isolation modules contained in one I/O cabinet is provided as Attachment 3 (Remote I/O Equipment Hardware Acceptance Test Procedure for NUS Corp./Baltimore Gas and Electric Company, Calvert Cliffs Data Acquisition System, dated February 20, 1984). Modules in other cabinets have undergone similar testing and their test reports are available, if requested. Abnormalities or non-conformances encountered during testing are documented and dispositioned per Section 3 of the test report.

B. Maximum design withstand voltage is 600V sustained and 1250V surge per IEEE Standard 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. A representative sample of isolation modules was tested to ensure no change of output data and no change in functionality due to the surge test. The results are acceptable. The test procedure and acceptance criteria are described in Attachment 3.

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 systems commensurate with original plant electrical design criteria.

7. Human Factors Program

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 integrated into the new plant computer which includes one 19-inch and one 25-inch plant computer monitor per unit mounted on the control boards, one 13-inch SPDS monitor per unit and one 13-inch plant computer monitor capable of displaying either unit all mounted on the senior operator's desk (see Attachment 4), one 13-inch plant computer monitor per unit mounted on the operator's desk, one plant computer monitor capable of displaying either unit mounted on the shift supervisor's console, and one 13-inch SPDS monitor per unit located in the Technical Support Center.

The SPDS will provide several displays organized under the following 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 in place. 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 (2 pages)

- Alarm/Indication
- Point Status

Reactivity (3 pages)

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

RCS Pressure and Inventory (4 pages)

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

Core/RCS Heat Removal (7 pages)

- Alarm/Indication
- Point Status
- CET Map
- CET Trend

Containment Environment (2 pages)

- Alarm/Indication
- Point Status

Containment Isolation (2 pages)

- Alarm/Indication
- Point Status

Radioactivity Control (2 pages)

- Alarm/Indication
- Point Status

Vital Auxiliaries (3 pages)

- Alarm/Indication
- Point Status
- Electric Bus Mimic

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.

Attachment 5 provides the Plant Operating Summary and all the Critical Safety Functions Alarm/Indication display formats.

Display Format Hierarchy

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. Once in a CSF, the user can page down or up, within a CSF, using the "PAGE FWD" or "PAGE 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 inverse 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 inverse video technique.

Location and Readability

The principal users of the SPDS will be the Shift Supervisor and the Shift Technical Advisor (STA). The monitors are located such that they are readily accessible to both principal users. The SPDS displays are not complex in format and occupy less than 30% of the total screen. Alphanumeric characters are displayed using a 7x7 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.

8. Data Validation

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 inverse 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 inverse 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 inverse 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 inverse 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 inverse 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.

9. Safety Analysis

The SPDS will provide human-factored displays for critical safety functions to aid the control room personnel in rapidly and reliably determining the safety status of the plant and in assessing whether abnormal conditions warrant corrective actions by the operators to avoid a degraded core. The SPDS is designed to be available during all design basis events at the plant except for a seismic event. It is not single failure proof.

The human factors review is performed in conjunction with other design validation tasks. The resolution of human engineering discrepancies (HEDs) and any exceptions taken to NRC or industry guidelines are documented. The display formats satisfy the applicable functional guidelines specified in NUREGs 0696, 0700, and 0835.

The probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR is not increased. The SPDS is isolated from safety-related signals. It receives data via a link from the plant data acquisition system (DAS). The DAS is a two channel isolation and multiplexing system which will provide data base updates to the plant computer.

The possibility for an accident or malfunction of a different type than any evaluated previously in the FSAR is not created. The use of data redundancy to the extent practicable, human-factored displays, and a verification and validation program, will minimize the potential for misleading the operator. Since the redundancy and reliability of control room indications often exceeds that possible within the SPDS, the new functionally oriented emergency operating procedures (EOPs) contain instructions for plant operators to verify SPDS indications using control board indications prior to taking any corrective actions.

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.

SAFETY FUNCTION STATUS CHECK BASES
REACTOR TRIP
Figure 4-9a

The safety functions listed below and their respective criteria are those used to confirm the adequacy of the RT Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	INDICATION	RANGE	BASES
Reactivity Control	Reactor Power Decreasing and [Negative Startup Rate] and Not more than 1 CEA Bottom Light Not Lit or Borated per Tech Specs	Power Range Power Rate CEA Status Display	[0-125%] [-1 → 7 dpm] On/Off Light for each CEA	For all emergency events, the reactor must be shutdown. The criteria that no more than one CEA be stuck out or the RCS be borated observes typical Technical Specification requirements.
Maintenance of Vital Auxiliaries (AC & DC Power)	[<----------Plant Specific---------->			
RCS Inventory Control	[35"] ≤ Pressurizer Level ≤ [245"] and Charging and Letdown are being operated manually or automatically to maintain or restore pressurizer level and RCS ≥ [20°F] Subcooled and [No reactor vessel voiding as indicated by the RVLMS]	Pressurizer Level [RVLMS]	[0"-350"] [0-100%]	A value of [245"] ([70%] of range) was chosen as an upper limit for pressurizer level to account for instrument inaccuracies and other uncertainties. A value of [35"] ([10%] of range) was chosen as a lower limit to account for instrument inaccuracy. A [20°F] subcooling margin coexisting with a pressurizer level in the range [35" to 245"] indicates adequate RCS inventory control via a saturated bubble in the pressurizer.

SAFETY FUNCTION STATUS CHECK BASES
REACTOR TRIP
Figure 4-9b

The safety functions listed below and their respective criteria are those used to confirm the adequacy of the RT Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	INDICATION	RANGE	BASES
RCS Inventory Control (Cont'd)				An uncomplicated reactor trip should not result in reactor vessel voiding.
RCS Pressure Control	[1700 psia] < Pressurizer Pressure < [2350 psia] and Pressurizer heaters and spray are being operated manually or automatically to maintain or restore pressurizer pressure to within the limits of the P/T curves, Figure 4-1.	Pressurizer Pressure	[1500-2500 psia]/. [0-1600 psia]	[1700 psia] corresponds to the SIAS alarm setpoint. [2350 psia] is the high pressure alarm setpoint. Best estimate analysis shows that the selected events will fall within the above range.
Core Heat Removal	$T_H - T_C$ < [10°F] and RCS ≥ [20°F] subcooled	T_H T_C [Subcooled Margin Monitor]	[520°-610°F] [0°-600°F] [0°-100°F]	Best estimate analysis demonstrates that S/G ΔT will be less than [10°F] in the steaming loop with RCPs running and at least one S/G steaming. [20°F] subcooled margin is based on engineering judgement to assure adequate core cooling accounting for temperature variations in the RCS. Best Estimate analysis shows that the noted events will fall in the selected ranges.

SAFETY FUNCTION STATUS CHECK BASES
REACTOR TRIP
Figure 4-9c

The safety functions listed below and their respective criteria are those used to confirm the adequacy of the RT Guideline in mitigating the event.

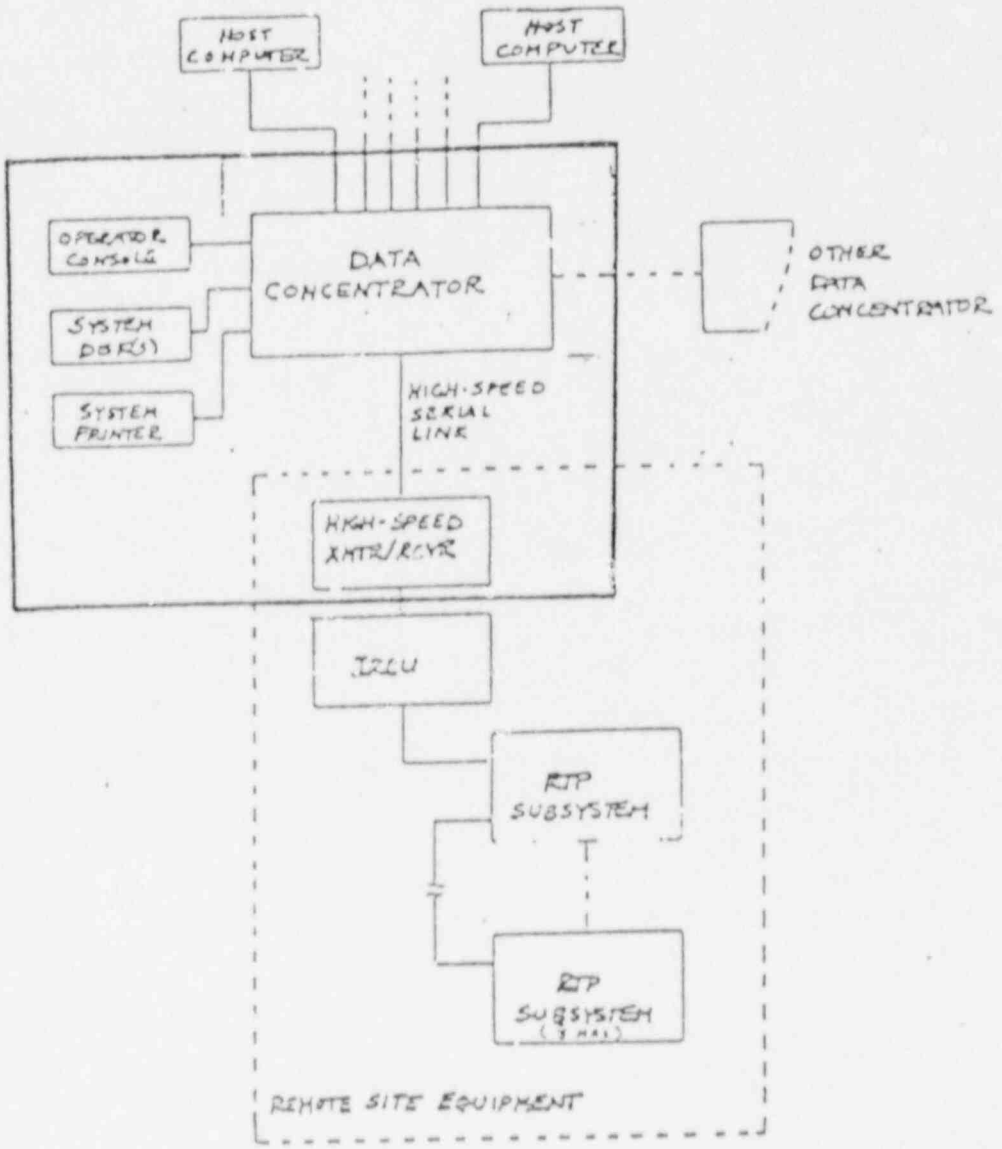
SAFETY FUNCTION	ACCEPTANCE CRITERIA	INDICATION	RANGE	BASES
RCS Heat Removal	a) At least one S/G has level: i) within the normal level band with feedwater available to maintain the level or ii) being restored by a feedwater flow > [150 gpm] and b) RCS T_{ave} is < [545°F]	Steam Generator Level	[+63.5" - (-)116.5"]	Decay heat levels may not be high enough to require a feedwater flow of [150 gpm]. If this is the case, once steam generator level is returned to the zero power level band and feedwater remains available to maintain that level, then RCS heat removal is being satisfied. [545°F] is based on control program for atmospheric dump valves and turbine bypass valves, and best estimate analysis.
Containment Isolation	Containment Pressure < [1.5 psig]	Containment Pressure	[0-60 psig] [0-15 psig]	[1.5 psig] is based on the containment pressure alarm. It is not expected, for the selected events, that containment pressure will increase to the alarm setpoint.
	and			
	No Containment Area Radiation Monitors Alarming	Containment Area Radiation Monitors	Alarming - Not Alarming	During an uncomplicated reactor trip there should be no radiation in containment. The indicators should not be alarming.
	and			
	No Steam Plant Activity Monitors Alarming	Steam Plant Radiation Monitors	Alarming - Not Alarming	Steam plant activity is an indication of an SGTR and is not anticipated for a RT.

SAFETY FUNCTION STATUS CHECK BASES
REACTOR TRIP
Figure 4-9d

The safety functions listed below and their respective criteria are those used to confirm the adequacy of the RT Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	INDICATION	RANGE	BASES
Containment Temperature and Pressure Control	Containment Pressure < [1.5 psig]	Containment Pressure	[0-60 psig] [0-15 psig]	[1.5 psig] is based on the containment pressure alarm. It is not expected, for the selected events, that containment pressure will increase to the alarm setpoint.
	and			
	Containment Temperature < [120°F]	Containment Temperature	[50°-300°F]	Maximum normal expected average containment air temperature.
Containment Combustible Gas Control	H_2 < [2%]	[<----------Plant Specific---------- ----------->]		

ATTACHMENT 2



DATA ACQUISITION SYSTEM (TYPICAL CHANNEL)