SPDS PROGRESS REVIEW
LASALLE UNITS 1 AND 2

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Prepared for
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SPDS Progress Review
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SUMMARY

An NRC team visited the LaSalle site on July 22, 23 and 24, 1985, to observe the installed SPDS. The team included a member of the NRC's Human Factors Engineering Branch and contractors from Science Applications International Corporation (SAIC) and Comex Corporation. The team reviewed the design, installation, testing, and operation of the LaSalle SPDS. This was one of six visits to representative nuclear power plants with operating SPDSs undertaken to ascertain the status of SPDS implementation and to obtain information regarding the general need for post-implementation audits of operating SPDSs.

On December 31, 1982, the LaSalle SPDS was declared operational to meet a Commonwealth Edison Company (CECo) licensing commitment. As presently installed, the system is unacceptable in that it does not provide a means of rapid and reliable assessment of plant status in emergencies. The SPDS is operational in the control room but operators expressed unanimous opposition to the system. Reasons for the poor operator acceptance centered on the following factors; (1) the system is highly unreliable; (2) the system was designed and installed with very little operator involvement; (3) the information displayed by the system is frequently incorrect and could mislead the operators; (4) the display is barely readable because of its location; and (5) the operating procedures caution against use of the system in an emergency.

During the three day site visit, the review team found numerous specific problems with the system. Even though the SPDS was installed in the control room and declared operational, it failed to provide valid, accurate, or reliable information. The system frequently displayed invalid off-normal conditions because of calibration and software errors. During the frequent times when the process computer was not in service, the SPDS displays remained activated, thus providing information which was not current and potentially misleading. One display was observed to show an erroneous Anticipated Transient Without Scram (ATWS) indication, an erroneous high suppression pool level and an erroneous radiation release to the atmosphere.

System Verification and Validation (V&V) is not scheduled until 1986 when all CECo systems are to be reviewed after-the-fact. The training program has been inadequate (about one hour in total) and is not always included in requalification training. The system has not been integrated into reactor operations and frequently provides information which is inconsistent with other control room instrumentation.

The parameters selected for display were found acceptable in the NRC's Safety Evaluation Report. The parameters are functionally grouped,

demarcated, and color coordinated and are continuously displayed on a one-page display format. The LaSalle operators readily use other computer-generated displays such as system mimics. However, because of the negative features noted above, the operators do not use the SPDS. A significant commitment on the part of the utility would be needed to improve the system to the point that it could become an effective operator aid.

SPDS PROGRESS REVIEW
LaSALLE 1 AND 2

July 22-24, 1985

1. SYSTEM OBJECTIVES (Initiation Phase)

1.1 Plant conditions for which the SPDS is intended to be used.

The licensee did not indicate specific operating conditions under which the LaSalle SPDS is to be used; however, the installation appears to be most useful when an off-normal condition occurs during normal power operations. In point of fact, the licensee seems to go out of his way to make sure the SPDS is not used. The following quotations are taken from the control room instructions to the plant operators (see Attachment D):

"CAUTION This document/drawing is for administrative reference only. It shall not be used for maintenance, operation, design or ASME/Tech spec related activities."

"D. Precautions 1. The SPDS display is not intended to provide sufficient indication to justify direct operator action on reactor or auxiliary system controls. The operator should refer to additional panel indications and alarms to confirm system status before taking action in response to an SPDS System Alarm."

1.2 Modes of plant operation in which SPDS is to be available for use.

The SPDS is intended to be maintained in an operable condition and displayed during all modes of plant operation.

1.3 Functional requirements

1.3.1 Critical Safety Functions.

The licensee has included coverage of all critical safety functions on one top-level display (page). Because of this "one page" SPDS design, compromises have necessarily been made such as the use of wide-range scales only, with no provision for narrow-range presentation on the SPDS. See Attachment A for parameters displayed.

1.3.2 Intended users.

The licensee's procedures do not identify specific control room users for the SPDS prior to or during an emergency. All licensed operators receive training in the SPDS, but it is general training covering its intended use and its design rather than its operational implementation. Discussions with operators indicated that the user who would probably use it the most would be the Shift Control Room Engineer, or SCRE, (i.e., STA during emergency conditions).

1.4 Relation to other NUREG-0737 Supplement 1 initiatives.

- Was the EOP upgrade program integrated into the SPDS?

The SPDS was designed and built without any intent to integrate emergency actions as called out in LaSalle General Abnormal (i.e., EOPs) with the SPDS. It stands alone.

- Was the SPDS integrated into the DCRDR? Describe current status of DCRDR relative to SPDS status.

The DCRDR was in progress at the time of the SPDS visit. The SPDS will be treated as any other CRT during the DCRDR.

- Are Reg. Guide 1.97 parameters used to feed SPDS?

Reg. Guide 1.97	LaSalle SPDS
1. Neutron Flux	RX POWER
2. Control Rod Position	ATWS feature of the RX POWER bar
3. RCS Pressure	RX Pressure
4. Drywell Pressure	DW PRESS
5. Primary Containment Isolation Valve Position	PCIS
6. Primary Containment Radiation	CONTAIN RAD
7. Suppression Pool Water Level	SUPP LVL
8. Effluent Radioactivity	RAD RELEASE
9. Suppression Pool Water Temperature	SUPP TMP
10. Drywell Atmosphere Temperature	DW TMP
11. Primary System Safety Relief Valves	SRV
12. Core Spray Flow	CORE SPRAY

The SPDS is fed from the plant process computer for the most part utilizing and manipulating parameters which were already there.

- Does emergency response structure necessitate SPDS in TSC or EOF?

The process computer (Honeywell) SPDS display is available in the TSC, and it can be called up from the Prime computer in the EOF.

- Does the SPDS supply a portion of the ERF data acquisition system?

Yes, as described in the answer above.

1.5 Verification, Validation, and Testing Program

- Was a program plan developed? Is it available for review?

There is a corporate V&V plan which is designed for application to all of the CECo reactors. However, the plan is being applied after the fact and not in parallel with the design process. The Dresden plant will be the first BWR to be validated under this system. Test cases are being developed by S. Levy and Associates--different personnel from those who developed the algorithms for the system design. A two-person V&V group has been designated in the Station Nuclear Engineering Department at the Corporate office. They are supported by plant personnel who were not involved in the design of the SPDS.

- Was the plan executed by the SPDS development group or by an independent party? Identify the group and their working relationship to the development group.

The plan has not been executed. See above for the groups involved.

- Did the plan include a process for review and analyses of the SPDS requirements?

The post installation and acceptance V&V plan attempts to follow a plan which is basically designed to be implemented during the design process. This is described in an E. Douglas Swartz (CECo) 29 December 1983 letter to Harold Denton (USNRC). Inasmuch as the system is installed, it will be very costly to fix any requirements discrepancies which show up in the V&V.

2. SYSTEM DESIGN (Development Phase)

2.1 Design Requirements

2.1.1 Events for which the SPDS can be used.

The SPDS is primarily useful to note problems occurring during normal power operations. There is some utility during other plant operating conditions; however, there are no design features which will "normalize" the display for off-power operational situations. For instance, during shutdown it is common to fill the pressure vessel beyond the high level alarm point. The reactor level bar graph will be red during this condition and it provides a false indication of plant status for this operating mode.

2.1.2 Parameter selection

Parameters displayed are listed in Attachment A.

The criteria for parameter selection is covered in the CECo August 30, 1984, letter to Harold Denton, "Response to NRC Request for Information

SPDS." The parameters described in Section 5.0 commencing on page 4 of that letter appear to cover the critical safety functions adequately. As there is only one "page" in the SPDS, the problem becomes one of accommodating a great deal of information on one display, and this is where it suffers.

It was also noted that the LGAs are presently being rewritten to incorporate the BWR Owners Group Rev. 3 which will incorporate the instrumentation to monitor secondary containment. It is not planned to include these parameters in the SPDS and, in fact, there is no room for them.

2.1.3 Basis for establishing display requirements.

The display format was generated by an in-house working group with human factors input based on a BWR Owners Group concept, and operational input from former plant operators. S. Levy and Associates constructed the algorithm from the requirements and made recommendations as to format and text. Some were implemented and some (mostly text prompts) were not. Current operational personnel input was lacking in the process. This is probably a factor in the low regard which the operators have for the system. All operators interviewed pay little or no attention to the SPDS.

2.1.4 Basis for logic used for CSFs.

The SPDS stands alone and was not designed with the idea of supporting the LGAs (EOPs). It is a system designed to meet the NRC's requirements with minimal effort, as quickly as possible. It was the result of an engineering study utilizing the proper technical and human factors disciplines, but with the above design goal.

2.1.5 Description of SPDS logic

The SPDS logic is described in the August 30 letter mentioned above.

2.2 Design Specifications - Software

2.2.1 Software Design, Programming, and V&V

SPDS Design Stage

- What was the process used to develop the system and subsystem specifications for the analysts and programmers?

Saul Levy, Inc. designed the algorithms used to support the SPDS function requirements in the LaSalle operating environment. This was done independently from the Commonwealth Edison SPDS team work. The information is contained in a single volume.

This report contained Parameter and algorithm descriptions; Algorithm symbols; Input/output signal lists; Algorithms; and Message lists. Reference: S. Levy, Inc. Report, SLI-8123, Rev. 1, "LaSalle Units I and II

Safety Parameter Display System," August 1983. This report was not docketed.

- How were human factors considerations factored into the SPDS design process?

The licensee stated that the human factors considerations were primarily the responsibility of the Commonwealth Edison SPDS development group. They used formal checklists which were derived from NUREG-0835, NUREG-0700 and other sources. Human factors aspects of display design include:

- o Functional grouping of the parameters within the display. Reactor system parameters (RX LEVEL, RX PRESS, CORE SPRAY and SRV) are all grouped on the left. Containment parameters (DW PRESS, DW TMP, SUPP LVL, SUPP TMP, PCIS, and CONTAIN RAD) are functionally grouped in the center of the display. Reactivity control (TX POWER) and radioactivity control (RAD RELEASE) are located on the right of the display.

- o The functionally grouped parameters were designed with functional demarcation.

- o Color coding was designed with consistency with the control room.

- o Readability requirements for 14 foot readability, but the readability of the installed system is a problem for the operators.

- What was the process used to define the SPDS software specifications for the programmers?

The program and data base specifications were defined in the S. Levy document referenced above.

- Was a Verification/Validation and Test plan developed?

A corporate verification and validation plan is being developed and will be implemented in the fall of 1986. The details of this plan were not available at the time of the audit.

- Did the V/V&T team generate design-based test scenarios?

Yes, the LaSalle SPDS development team generated the test codes to evaluate all algorithms.

- Did the V/V&T process include the review and analysis of SPDS design?

Preliminary design integrity checks were performed in the field. Preliminary design evaluation checks were performed during software checks.

SPDS Programming Stage

- Was an SPDS Users Manual developed for the SPDS users (Plant operations staff such as shift supervisors and senior reactor operators)?

LaSalle procedure, LOP-CX-102, Revision 0, SPDS Display System, December 29, 1932, was developed to explain the function of and operator response to the safety parameter display system. The procedure is accompanied by a "CAUTION" that it is not to be used for operation. This procedure is included as Attachment D to this report.

- Operations Manual

The Program Specifications document will be used to develop this manual for LaSalle in order to accommodate future maintenance and modification. (See Attachment C.)

- Was an Initial Software Test Case Specification developed by the V/V&T team during this stage?

The basic set of test cases were developed by the LaSalle SPDS development systems analysts.

- Did the V/V&T team review and analyze the Users Manual?

This is done by the LaSalle SPDS development group's systems analysts.

- Did the V/V&T team perform a review and analyze the project requirement?

This will be done in the generic Corporate verification and validation program which is planned for the fall of 1985.

- Program Maintenance Manual

The Program Maintenance Manual is basically the Design Specification Document. It contains input and output flow diagram modules. In order to perform corrective or perfective maintenance, the LaSalle programmers have to complete a Program Control Change form.

2.2.2 Software development quality control procedures?

There were no formalized software Q.A. procedures in place. The programmer did his own test cases, and there were no peer reviews.

2.2.3 Software reliability

The SPDS was internally programmed in assembly language and was installed in the Honeywell process computer. There are two process computers, but technical support personnel have little respect for computer generated information as the computer (not a safety-related system) is frequently down.

2.2.4 Utility of displayed information

- Define location of each parameter for each CSF.

This information is adequately described in the August 30, 1984, letter mentioned above.

- Display indicates departure from normal conditions?

Yes, but generally based on normal at-power operating conditions.

- Degree of departure?

The bar graph displays indicate a degree of departure based on limit lines which are keyed to normal operating points and tech spec limits. Numerical values are shown above the bar graphs as are point-to-point trends. The status boxes indicate normal and off-normal states only.

- SPDS has capability to store and recall information?

The process computer which feeds the SPDS does not have this capability. The process computer does "dump" to the Prime computer which does have this capability.

- SPDS has capability to display trends?

No, but the Prime computer does have this capability, and it is frequently used by the operators.

- Is command structure appropriate to the complexity of the software? ... to the sophistication of the user?

The display holds a great deal of information. As it is a one-page SPDS, always displayed, it requires little operator manipulation. He must silence a computer alarm to stop the display from flashing in an alarm condition. However, operators appear to have such a low regard for the system, that flashing alarms (in one case witnessed) are not even acknowledged.

- Upon departure from normal conditions, does the SPDS direct the operator to the appropriate EOP? If not, is this a significant deficiency?

There is no relationship between the EOPs and the SPDS. Given that the SPDS is intended to be "just another annunciator," and that all actions are taken based on board instrumentation, it doesn't hurt anything. However, it points out the main deficiency in the SPDS system overall -- it was not conceived or intended to be integrated with the existing plant instrumentation or with other post-TMI initiatives; therefore, it is ignored by the operators.

2.2.5 Potential for misleading operators

Two main problems for misleading operators exist. The SPDS frequently displays invalid off-normal conditions because of programming bugs and inadequate calibration. The computer is frequently down, and the displayed image remains on the screen when the computer is down. It does display out-of-date information. Trained operators always look at the clock display first to see if it is moving. If not, they know it is out of commission. A new operator might miss this subtlety. Also, during the review the display was frequently indicating off-normal conditions because of input problems or actual off-normal conditions for power operations with the plant not at power. Again, a new operator might initiate some unwarranted action based on the display.

The SPDS program does have a high priority of execution within the process computer hierarchy.

2.2.6 Software security

There are administrative controls over unauthorized modifications.

2.3 Design Specifications - Hardware

2.3.1 Design verification and validation

Design verification and validation has not yet been performed.

2.3.2 Human Factors Engineering

Attachment B provides a human factors assessment of the SPDS displays.

2.3.3 Reliability

The SPDS uses multiple inputs from the process computer which are examined for range. Valid inputs are compared and/or combined to provide a value which is displayed. There are two computers which are supplied from uninterruptible power supplies.

The sensors which supply signals to the process computer and the isolating devices are classified 1E.

2.3.4 Electrical Isolation

Validyne CM-249 isolator modulators are used to isolate safety-related signals from the process computer and therefore the SPDS. These isolators were previously qualified and so no additional qualification needed to be done when the SPDS was back-fitted to the process computer data points.

3. IMPLEMENTATION

3.1 Procurement

Detailed software specifications for Dresden - a similar plant - were reviewed and found acceptable.

3.2 Installation

The SPDS was declared operational on December 31, 1982, to meet a CECo commitment. However, the V&V on the system has yet to be accomplished.

The algorithm logic used to combine the selected parameters to monitor the critical safety functions on the single page SPDS was prepared by a consultant and then modified and installed by CECo. The design goal of achieving an adequate SPDS on one page contributed to the complexity of software design.

3.3 System Verification and Validation

System verification and validation are yet to be accomplished. They will be accomplished after the fact on all CECo reactors. Validation of sensor values is accomplished under a normal plant maintenance and testing program. To validate the end-to-end data loop to the SPDS, the value of a parameter as read by the computer and/or SPDS display was compared with the value as indicated on control panel instrumentation.

4. TRAINING

4.1 Training recipients

Training is provided to all licensed operators as a part of their licensing qualification and requalification program. All operators received instruction on the SPDS prior to initial licensing. SPDS training is not always included in requalification training. Whether or not it is included is determined by the extent of changes made in the system.

4.2 Training Program Structure

The SPDS training is included in the portion of the program which also covers the process computer. About an hour is devoted to the SPDS. The training plan was reviewed for content. It adequately describes the intent of the SPDS and the sources and logic used in its software design and parameter selection. It also emphasizes that the SPDS indications will not be used to manipulate controls on the plant -- control room normal instruments will be used to verify the SPDS indications. The training plan and the plant operating procedures indicate that the integration of the SPDS into plant operating practices has not been accomplished. It is treated as just another annunciator and receives no special attention during normal operation or during emergency events.

The utility provides the training, which is primarily in the classroom, supplemented by a required reading program to inform operators of minor changes.

The personnel who man the TSC and EOF received separate training on the SPDS covering its implementation at those locations.

At the present time there is no SPDS in the simulator, but one will be installed.

The licensee's training representative during the review stated that all SPDS users were trained in the system prior to its being declared operational. However, when training records were requested it was pointed out that records which would indicate that an individual did in fact receive the training do not exist. As the SPDS training is part of the licensing training, the only record maintained is the record of satisfactory licensing examination completion. Company policy makes each trainee responsible for his own course attendance -- the bottom line is that he pass the exam. If he can do that, they don't care whether or not he attends class.

4.3 Training Program Content

As previously stated, the training program on the SPDS is devoted to an explanation of the intended use of the system as an annunciator to give a quick look at plant conditions, and describes the functions presented and the parameters and logic which governs their presentation on the display.

The training program does not cover the integration of the SPDS into the various modes of plant operation or into the LGAs (EOPs).

The licensee explained that the SPDS may or may not be covered on the SRO/RO license examinations. Of those operators interviewed, none had had any questions on their examinations. However, they did remember questions on their weekly quizzes covering the SPDS.

The SPDS may or may not be included in annual requalification training depending on the extent of changes in the system since the original training was done. Major changes would be included in the formal classroom requalification training, but minor changes are handled through a required reading training program.

5. OPERATION

The reviewers saw no evidence that the SPDS is used by the operators. During interviews, all operators expressed a significant disdain for the system. Some of this scorn is based on the fact that the process computer is frequently down. Some may be based on the fact that current operators were not involved heavily during the design and implementation of the system, and some may be because of management's decision to implement a system which met the NRC requirement as quickly and inexpensively as possible -- without any consideration of its integration into the plant operational or emergency procedures.

The reviewers noted that operators failed to silence alarm conditions appearing erroneously on the display during normal operation of the plant. One channel of APRMs gave a false ATWS indication on the reactor power display bar graph. As the cause was known, the operators tended to ignore it. A similar situation was noted on the Rad Release alarm block. The latter is caused by the inability to change the alarm set point in the computer. The licensee intends to fix this item by taking the signal from the plant panel instrumentation.

The operator interviews consisted of interviews with a shift engineer and senior control room operator. The main comments from the interviews are listed below.

- The SPDS provides the operators with an instantaneous reading of parameter status. The operators indicated that it would be more valuable to display parameter trend rather than instantaneous values.

- The display remains frozen on the screen when computer goes out of commission. The operators indicated that this could mislead an operator, so they always check the time clock which will be stopped if the computer is down.

- The shift engineer was penalized because he did not document the fact that SPDS was out of commission during a reactor trip. The NRC resident inspector informed him that even though the SPDS is not safety grade, its status during an emergency must be reported to the NRC as a tech spec violation. This causes the shift engineer to look upon the SPDS as a device which can only "bite" him rather than aid him.

- The SPDS is unreliable.

- The operators have a negative attitude toward the SPDS. But, that is not to say that they resist computer generated information. They do like and use other computer generated information such as system status diagrams.

6. MAINTENANCE

6.1 Software Maintenance

There is a formal procedure to control software modifications (LTP-1800-18, Rev. 0 dated August 1984).

6.2 Hardware Maintenance

There are procedures for calibration of sensors and for surveillance. There is no SPDS service manual as the system is basically a software system and functions in conjunction with the process computer. Maintenance appears to be based on the "fix it when it breaks" concept rather than on a preventative maintenance program.

6.3 Configuration Control

The licensee utilizes a change control system which has many checks and balances and utilizes human factors personnel in the approval process. Documentation of changes and approvals seems adequate.

ATTACHMENT A

CRITICAL SAFETY FUNCTION PARAMETERS

ATTACHMENT A - Critical Safety Function Parameters

CRITICAL SAFETY FUNCTION

1. Reactivity Control

APRMs (6)
SRMs (4)

2. Reactor Core Cooling
Primary Heat Removal

Reactor Water Level (Upset Range/Wide Range/Wide Range/Fuel Zone Range)
Core Spray

3. Reactor Coolant System
Integrity

Reactor Pressure (Wide Range/Narrow Range)
Drywell Pressure (Wide Range/Narrow Range)
Containment Activity
Safety Relief Valve (SRV) Position
Primary Containment Isolation System (PCIS) 1 and 2 Valve Positions

4. Radioactivity Control

Off Gas - Pretreatment Monitor
SBGT Radiation (Low Range/Mid Range/High Range)
SGBT Flow
Main Chimney Radiation
Main Chimney Flow
Liquid Radwaste - Discharge Monitor
Plant Service Water - Discharge Monitor
RHR Loop "A" - Discharge Monitor
RHR Loop "B" - Discharge Monitor

5. Containment Conditions

Drywell Pressure (Wide Range/Narrow Range)
Drywell Temperature
Suppression Pool Level (Wide Range/Narrow Range)
Suppression Pool Temperature
Primary Containment Isolation System (PCIS) 1 and 2 Valve Position

ATTACHMENT B

HUMAN FACTORS ENGINEERING ASSESSMENT

ATTACHMENT B

HUMAN FACTORS ENGINEERING ASSESSMENT

Evaluation plan to assess human factors principles in VDU designs. Adapted from "Human Engineering Guidelines for the Evaluation and Assessment of Video Display Units" W.E. Gilmore, May, 1985.

Score: OK or NO

I. Visual Displays

a. Evaluate the display for image quality and legibility (by visual observation; adjust brightness control)

1.	Flicker	OK
2.	Contrast Ratio	OK except for red
3.	Brightness	OK
4.	Resolution/Sharpness	NO
5.	Phospher Persistence	
6.	Glare Control	OK
7.	Screen Resolution	OK

Comments:

b. Screen structure and content

1. Cursor Design

2. Text (Prose) Characteristics (text content evaluated later)

a.	Concrete	OK
b.	Organized, grouped	OK
c.	Easy to comprehend	OK
d.	Avoids double-negatives	OK
e.	consistent format	OK

3. Labeling

a.	Concise	
b.	Familiar	OK
c.	Visibility/legibility	Visibility - OK Legibility - NO
d.	Capital vs. lower case	Capital
e.	Size graduation	Depends on parameter
f.	Distinct from data	
g.	Consistency	OK

4. Messages

a.	Factual	OK
b.	Short and meaningful	OK
c.	Simple sentences	N/A

d. Stated in the affirmative
e. Useful/understandable — Understandable

5. Abbreviations

6. Error statements

a.	Entry error is flagged	OK - error signal in cyan (blue)
b.	Statement is specific	
c.	Brief and informative	OK
d.	Neutral/polite wording	OK
e.	Minimize disruption	OK
f.	System response time	5 sec

7. Alphanumerics

a.	Code is consistent/standard	OK
b.	Meaningful and short	OK

8. Data Display (obtain a sample page of displayed data)

a.	Data presented to reduce search time	OK
b.	Directly useful for task	OK
c.	Consistent/standard	OK
d.	Does not rely on user memory	OK
e.	Info limited to user needs	NO - rate of change
f.	Info perceptually organized	OK

9. Data Entry

a.	Devoted function keys or simple command	N/A
b.	Distinctive prompts	

Comments:

C. Alphanumeric Characters

1.	Font or style	Caps
2.	Character size and proportion	OK
3.	Character case	OK
4.	Emitter size, shape, spacing	OK

Comments:

D. Screen Organization and Layout

1. Screen Size (Inspect from normal viewing distance)
19" diagonal

a. Information is discriminative and legible. NO for letters/YES for bars and blocks

2. Grouping

   a. Data is functionally or meaningfully grouped. OK
   b. Grouped data is consistently placed. OK

3. Display Density

   a. Info density is reduced. OK

4. Display Partitioning

   a. Techniques applied to organize screen elements. OK - grouped by white demarcation

5. Frame Specs/Info Location N/A
6. Interframe Considerations N/A

E. Visual Coding Dimensions (Identify all coding dimensions)

1. Color
   Yellow - numbers for bars
   White - actual parameter number
   Blue - outlines and out of spec
   Red - out of spec
   Green - normal
2. Geometric/Shape Coding Geometric
3. Pictorial Coding
4. Magnitude Coding
5. Visual Number Coding
6. Inclination Coding

(Collect relevant dimensions for evaluation against guidelines.)

Use of Color -

- o Identify all uses and contexts of color (meanings) (Text, background, symbols, lines, etc.)
- o Is color used as a redundant means to attract attention? (Ex: redundant to blinking) Blue
- o Identify which colors displayed simultaneously and which are adjacent to one another. Red on Red / Red on Green
- o Does display have a control to adjust brightness? YES
  Does it affect color contrast? YES
- o What colors used for fine detailed text? (On what background?)
- o Does use of color exhibit cognitive fidelity with user expectations? (Look at other uses or contexts of color in control room and particularly displayed information.)
- o Do any colors appear blurred?

- o Is any information difficult to read or perceive <u>because</u> of color?

F. Enhancement Coding Dimensions

1. Brightness
2. Blink Coding
3. Image Reversal
4. Auditory Coding
5. Voice Coding
6. Audio-Visual Warning and Signal Devices

a.	Visible Alarms Supplement Audible Ones for high noise conditions.	NO
b.	Visible indication is within 60 degrees of direct line of sight.	OK
c.	Dimensions applied to visible indication for attention-getting and to distinguish priorities.	OK
d.	Dimensions combined for high attention-getting value.	OK
e.	Visible dimensions sensed from long-viewing distance.	OK
f.	Absence of visual indication denotes normal.	OK

(Collect relevant dimension and applications for later evaluation against guidelines.)

G. Dynamic Display Characteristics

(Observe screen in a dynamic mode to assure that dynamic features can be detected and that dynamic features do not legibility of critical information.

1.	Display (animated) motion	OK
2.	Digital counters	N/A
3.	Rate of change is perceivable	YES
4.	Graphic displays are updated at a rate consistent with operator data handling capabilities	

H. Information Formats

(Short of a task analysis, assess the formats capability to meet operator information requirements.)

1.	Format provides concise information needs	OK
2.	Info is limited to immediate needs and direct to actions	OK
3.	Info is directly usable	OK
4.	Graphic display techniques are limited in variety	OK

5.	Info is displayed to appropriate limits and precision required for actions/decisions	
6.	Redundancy is avoided unless needed for reliability	OK
7.	Operator and maintainer info is not combined on a a single display	N/A
8.	Failure of display is clear	NO
9.	Demand and actual status is differentiated	N/A
10.	Format is most natural or expected	OK
11.	Format is effective for environment and viewing conditions	
12.	Formats exhibit "good" H.F. standards:	
	a. Legible	NO
	b. Uncluttered	OK
	c. Consistent	OK
	d. Labeled	OK
	e. Visible	NO
	f. Conspicuous	NO
	g. Interpretable	OK
13.	All parts represent the whole (as in multiple dimensional formats) and are parameters legible and discriminable	
14.	Do formats that attempt to provide pattern recognition cues actually aid detection of abnormal events?	YES

Comments:

II. Controls

A. Keyboard Layout and Dimensions N/A

1. Keystroke feedback
2. Key actuation force
3. Key-rollover
4. Key travel
5. Key color/labeling characteristics
6. Key dimension/spacing
7. Keyboard slope
8. Keyboard thickness
9. Special function keys
10. Auxiliary numeric key set
11. Alternate input device

Comments:

III. Control/Display Integration N/A

A. User Dialogue

1. Dialogue design suited to task.
2. Menu design

   a. Compatible with control action
   b. facilitates accuracy/speed
   c. Menu hierarchically organized

3. Command language (N/A)
4. Query language (N/A)
5. Natural language

Comments:

B. System Feedback to User Actions
(Question operators and observe VDU)

1. Display Update Rate

   a. Time lag between component and display value
   b. Parameter values and realtime time
   c. Update time 3 s or less

2. Response Time

   a. Values appropriate for task or 2-4 s max

3. System Status Indication

   a. Adequacy of indicator

4. Routine Status Information

   a. Error messages, prompts OK
   b. Alarm setting basis given i.e., variables covered and critical values OK
   c. System gives up to date account OK

5. Performance Job Aids

   a. User finds system easy to use and helpful for the task (Assess these features for their effectiveness in "closing the loop" between the operator-machine interface)

IV. Workplace Layout

A. Anthropometric Aspects of the VDU Workplace

1.	Keyboard dimensions	N/A
2.	Screen height and viewing angle	Too high
3.	Viewing distance	Poor readability
4.	Screen orientation (tilt)	Not enough
5.	Chair characteristics	N/A
6.	Hard copy printer	N/A
7.	Health and safety factors	N/A

Comments:

ATTACHMENT C

COMMONWEALTH EDISON CO.
DRESDEN, QUAD CITIES, LaSALLE
SAFETY PARAMETER DISPLAY SYSTEM
FUNCTIONAL SPECIFICATION

COMMONWEALTH EDISON CO.

DRESDEN, QUAD CITIES, LASALLE

SAFETY PARAMETER DISPLAY SYSTEM

FUNCTIONAL SPECIFICATION

Rev. 1
2-16-83

1. PURPOSE

The purpose of the Safety Parameter Display System (SPDS) is to satisfy the intent of NRC criteria contained in the NUREG-0585, NUREG-0660, and NUREG-0696.

2. OBJECTIVE

Provide one or more displays in the control room which will aid operating personnel to assess the safety status of the plant.

3.0 DEFINITIONS

The meaning of the words and terms, in context of their use in this specification, shall be in accordance with the following definitions.

3.1 Safe State of the Plant: A BWR nuclear plant is defined to be in a safe state when the core is adequately cooled; when reactivity is controlled; when the integrity of reactor coolant system and containment is maintained; and when in-plant and effluent (to environment) radiation levels are within specified limits.

3.2 Safety Parameter: The safety parameter is defined to be the quantitative/qualitative or binary measure of accomplishment or maintenance of the safety functions identified in Paragraph 3.1.

3.3 Safety Parameter Display System: The SPDS is defined to be a display system which will aid operating personnel to assess the safety status of the plant.

3.4 Verification: The verification is defined to be a procedure to obtain increased assurance that the indicated value represents the true value of a process variable.

3.5 Validation: The validation is defined to be confirmation of the input signal to be within the range of the sensor/instrument.

3.6 Primary Variable: The primary variables are defined to be the monitored variables that provide the most direct indication needed to assess the status/value of the safety parameter.

3.7 Isolation Valve Groups: Isolation valves to be monitored belong to two groups. Valves in Group 1 are on process lines that communicate directly with the reactor vessel and penetrate the primary containment. Valves in Group 2 are on process lines that do not directly communicate with the reactor vessel but penetrate the primary containment and communicate with the primary containment free space.

4.0 APPLICABLE DOCUMENTS

a. NUREG-0660

b. NUREG-0585, published October 1979

c. NRC SPDS Functional Specification Draft of July 8, 1980 (Part of NUREG-0696)

5.0 CRITERIA

5.1 The Safety Parameter Display (SPD) shall be located in the control room and shall attract the attention of the operating personnel when there exists a trend or condition towards degradation in the safety parameters of the plant.

5.2 The Safety Parameter Display (SPD) shall be located such that it is accessible and visible to operating personnel and be distinguishable from other displays.

5.3 The SPD shall not inhibit physical or visual access to operator interfaces with normal and operating systems located in the control room.

5.4 The SPD shall be designed for continuous operation.

5.5 The SPDS shall be capable of functioning properly in the environment present during normal and abnormal conditions.

5.6 The SPDS need not be designed to function during or after an Operating Basis Earthquake (OBE) event.

5.7 The SPDS shall be of proven high quality and reliability.

5.8 Range and accuracy of instrumentation shall be consistent with intended use.

5.9 Means shall be available to validate the parameters associated with the SPDS. Provision shall be made to alert operating personnel to any unsuccessful validation.

5.10 Any interface between the SPDS and the safety systems shall be through isolation means.

5.11 Design provisions shall be included in the interfaces between the SPDS and the non-safety systems to ensure the integrity of the SPDS.

5.12 Class 1E qualification of the SPDS is not required.

5.13 The SPDS need not satisfy the single failure criterion.

5.14 No operating personnel other than normal control room operating staff are required for SPDS operation.

5.15 The SPDS shall be designed and arranged to ensure operability and maintainability. In addition, the SPD design shall consider the following Human Engineering criteria:

a. Grouping by function and systems.

b. Presentation of information in directly usable form (minimal mental computing, transposition and interpolation).

c. Minimization of reflection and glare.

d. Consistent use of color, shape, size and location coding.

e. Orientation of information displays with respect to operators line of sight.

6.0 DESCRIPTION AND REQURIEMENTS

6.1 Scope: The SPDS shall present the value or status of the primary variables (see Paragraph 6.1.1) of the following safety parameters:

a. Core cooling

b. Reactivity

c. Reactor coolant system integrity

d. Containment integrity

e. Radioactivity release to the environment.

The SPDS constitutes the display of the primary variables associated with the above safety parameters. Additional variables currently displayed or available in the present control room design should be used by the operator for additional variable verification.

6.1.1 SPDS Safety Parameters and Associated Primary Variables

Parameter	Primary Variables
Core cooling	Reactor water level Core spray operation
Reactivity	SRM log count rate APRM % power
Reactor coolant system integrity	Reactor pressure, drywell pressure, Containment activity, RPV isolation,* Safety relief valve position

Containment integrity	Drywell pressure, Containment isolation valve position,* Suppression pool temperature Suppression pool level, Drywell temperature
Radioactivity release to environment	Radiation level at planned plant release points**.

6.2 Parameter Description: This paragraph provides the following information regarding each safety parameter:

a. Identification of the primary variables which are used by the SPDS to provide the measure of the safety parameter. In certain cases a brief analysis is included to demonstrate that the identified process variable(s) provides an appropriate measure of the safety parameter. References 1 and 2 provide additional explanation justifying parameter selection.

b. Identification of existing instrumentation associated with the primary varaibles. This information will enable the system designers to utilize as much existing instrumentation as practicable.

c. Identification of the existence of know error(s) in measured process variables and the plant conditions in which such error(s) may exist. The identification of these errors is provided for operator awareness to ensure verification of indications with other, diverse instruments.

d. Signal Verification/Validation. This information indicates the method used by the SPDS to validate the status/value of the parameter.

6.2.1 Core Cooling: The BWR normally operates under saturated conditions with approximately 70% void fraction at the core exit and with saturated steam in the upper region of the reactor pressure vessel (RPV). Since the BWR fluid is essentially saturated, it is not necessary to measure the transition from a subcooled to a saturated condition. Therefore, the primary method to assess adequate core cooling in BWR's is to use a direct measurement of reactor water level.

Analyses and measurements have confirmed that natural circulation capability is an inherent BWR feature. There are no traps which might block the natural circulation. Steam and noncondensibles all rise to the top during normal operation and during accident conditions. As long as there is adequate water level, there is

* Includes the valves in isolation Groups I and II.
** Includes off-gas pretreatment radiation, ventilation system release rates, and liquid effluent releases.

assurance of adequate core cooling. The reactor vessel water level is, therefore, the primary indication of the adequacy of core cooling in the BWR; conversely, an inadequate or decreasing water level is the indication of approach to inadequate core cooling.

For conditions when water level cannot be maintained or determined, core cooling is provided by operation of the core spray system. Measurement of design flow of either core spray subsystem is sufficient to verify adequate core cooling.

6.2.1.1 Instrumentation: Instrumentation of reactor water level generally consists of numerous indications of reactor water level to the reactor operator and are in full view, either on the reactor control console or nearby panels. These indications are comprised of the following:

a. Wide range level indicator

b. Wide range level recorders

c. Narrow range level indicators

d. Narrow range recorder

e. Fuel zone level indicator

f. Fuel zone level recorder

g. Shutdown range level indicators

The SPDS displays utilize 9 water level instruments at LaSalle and 7 water level instruments at Dresden and Quad Cities to develop a full range, composite water level signal (see References 1 and 2). The signals are compared and/or combined to provide the most accurate single value of water level available.

In extreme circumstances when water level cannot be determined by level instrumentation, core cooling is verified by measurement of design core spray flow. The SPDS displays use direct measurement of core spray flows taken from the core spray flow sensors (one low pressure (LP) and one high pressure (HP) at LaSalle and two LP's at Dresden and Quad Cities) as described in References 1 and 2.

6.2.1.2 Error Identification

No plant condition related errors are expected in the measurement of core spray flow rates.

6.2.1.2.1 Water Level Calibration Errors at High Drywell Temperatures:

a. Yarways. Possibility of instrument reading higher than actual water level.

b. Cold Reference Leg. Same general potential consequences as for Yarway instruments.

6.2.1.2.2 Water Level Errors Due to Flashing During Rapid Depressurization:

a. Yarways. Erratic behavior below 250 psia.

b. Cold Reference Leg. Possible erratic behavior below 118 psia.

6.2.1.2.3 Water Level Errors Due to Long-Term Boiling After Depress:rization (Both Instrument Types): Possible large errors developing slowly (time scale of hours) if drywell temperature remains above RPV saturation temperature (possible only for a small and intermediate steam break without filling RPV to the elevation of the break, or for loss of drywell coolers with depressurization at such a rate that drywell temperature exceeds RPV saturation temperature).

6.2.1.3 Signal Verification/Validation: References 1 and 2 identify the means of verification which will provide the most accurate value of reactor water level. Basically, verification is performed by cross correlation of readings from two or more sensors. The trend displays indicate the rise/fall of water level.

The core spray flow rates are verified by comparison of measured flow with calculated flow from pump head curves using measured pump discharge pressures (see References 1 and 2).

6.2.2 Reactivity: The neutron instruments shall be the primary variables for determining this parameter. In the event of a scram, the SRM's are inserted to monitor subcriticality.

6.2.2.1 Instrumentation: The SPDS displays will use the 4 SRM channels and the six APRM channels to display reactor power (see References 1 and 2)

6.2.2.2 Error Identification: The plant condition related SRM and APRM instrumentation errors are negligible.

6.2.2.3 Signal Verification/Validation: Comparison of redundant channel readings will be used to verify the SRM and APRM values. The readings will be selected or combined to provide the most accurate ·lue available as described in References 1 and 2.

6.2.3 Reactor Coolant System Integrity: This parameter can be assessed by monitoring the following variables:

a. Reactor Pressure

b. Drywell Pressure

c. Containment Activity

d. RPV Isolation

e. SRV positions

6.2.3.1 Instrumentation: Generally, all primary variables are indicated and/or recorded in the control room, and utilized by the SPDS displays as indicated in References 1 and 2.

6.2.3.1.1 Four reactor pressure signals are transmitted from separate pressure transmitters and used by the SPDS for reactor pressure indication as described in References 1 and 2.

6.2.3.1.2 The drywell pressure varies slightly during reactor operation and is monitored by three pressure sensors. The pressure fluctuates slightly as a result of barometric pressure changes and out-leakage. A pressure rise above the normally indicated values will indicate a possible leak within the drywell. Pressure exceeding the preset values will be annunciated in the main control room and safety action will be automatically initiated. The SPDS utilizes the pressure inputs as described in References 1 and 2 to display drywell pressure.

6.2.3.1.3 Containment activity may be used to determine reactor coolant system integrity by measuring radioactive release to the drywell. See Section 6.2.2 for additional description.

6.2.3.1.4 The reactor isolation is verified by position indication of RPV isolation valves and safety relief valves. Most of the isolation valve indicator lights are located on the ECCS bench board or containment status panel in the control room. The SRV position is determined by accoustic sensors installed at the SRV discharge lines (Dresden/Quad Cities) or by valve position limit switches installed on valve movement mechanisms (LaSalle). References 1 and 2 describe the use of these inputs by the SPDS display.

6.2.3.2 Error Identification: These process variables are not subject to large errors. Instrument accuracy is expected to deteriorate under adverse environmental conditions.

6.2.3.3 Signal Verification/Validation: These variables are verified as described in References 1 and 2. In some cases, redundant signals are combined to provide the most accurate value for the variable. Verification of isolation function is by determination of either of two redundant valves as being closed.

6.2.4 Containment Integrity: This parameter can be assessed by measuring the following process variables:

a. Drywell pressure

b. Containment Isolation (containment isolation valve position)

c. Suppression pool temperature

d. Suppression pool level

e. Drywell temperature

6.2.4.1 Instrumentation: Generally, all primary variables are indicated and/or recorded in the control room. The SPDS display of these variables is described in detail in References 1 and 2, and briefly below.

6.2.4.1.1 The display of drywell pressure was discussed in Section 6.2.4.1.2.

6.2.4.1.2 Containment isolation is determined by position indication of Group I and II containment isolation valves. Digital inputs from valve position limit switches will be monitored by the SPDS to assess successful isolation.

6.2.4.1.3 Suppression pool temperature is measured by thermocouples/RTD(s) distributed around the pool. The sensor inputs will be processed by the SPDS to determine the bulk pool temperature.

6.2.4.1.4 The suppression pool water level will be monitored by three independent water level instruments, one narrow range and two wide range.

6.2.4.1.5 The drywell temperatures are monitored by thermocouples/RTD's located in the drywell air space. Two local sensors at Dresden and Quad Cities, and four average temperature indications at LaSalle will be used by the SPDS to indicate drywell average temperature.

6.2.4.2 Error Identification: No plant condition related error is expected to be present in the following measurements.

a. Drywell pressure

b. Containment isolation (containment isolation valve position)

c. Suppression pool temperature

d. Suppression pool level

e. Drywell temperature

6.2.4.3 Signal Verification/Validation: Comparison of signals will be used for verification of the following primary variables as described in References 1 and 2:

a. Drywell pressure

b. Suppression pool temperature

c. Suppression pool level

d. Drywell temperature

For groups 1 and 2 there are two isolation valves in series for each process line. Position indication is provided for both valves. Isolation is verified if one of the two valves is closed.

6.2.5 Radioactivity Release to the Environment: This parameter can be assessed by monitoring the radioactivity at planned plant release points identified below. Further detail on the selection end description of these variables is provided in References 1 and 2.

a. Main plant chimney

b. Liquid Radwaste

c. Service Water Discharge*

d. RHR discharge*

e. Reactor Building Vent Exhaust (D/QC)

f. SBGT Exhaust (LaSalle)

g. Off Gas Pretreatment

6.2.5.1 Instrumentation:

6.2.5.1.1 The main plant chimney effluent activity shall be measured by instrumentation covering three ranges from 10^{-7} uCi/cc to 10^{5} uCi/cc. The measured activity will be mathematically combined with a measured flow rate to produce a release rate.

*Combined at Dresden/Quad Cities

6.2.5.1.2 The effluent paths from liquid radwaste, service water*, and RHR discharge* shall be monitored using existing radiation detectors. Increased levels of radioactivity in these effluent paths will be identified to the operator when preselected limits are exceeded.

6.2.5.1.3 The reactor building vent exhaust (D/QC) and the SBGT exhaust (LSCS) effluents shall be monitored the same as the main chimney identified above in 6.2.6.1.1.

6.2.5.1.4 The off gas pretreatment radiaton shall be measured using existing log radiation monitors (only one at LaSalle).

6.2.5.2 Error Identification: High area background radiation, plateout, or deposition could cause erroneously high readings and should be accounted for.

6.2.5.3 Signal Verification/Validation: Comparison of signals from overlapping ranges will be used by the SPDS to verify the Main Plant Chimney, Reactor Building Vent Exhaust, and SBGT Exhaust signals as described in References 1 and 2. Comparison of redundant off gas monitors at Dresden and Quad Cities will be used for signal verification.

6.3 REQUIREMENTS

6.3.1 Instrumentation Requirements

6.3.1.1 References 1 and 2 define the following for each primary variable:

a. Sensor(s)

b. Range

c. Validation/verification techniques

6.3.1.2 The SPDS power supplies shall match the SPDS equipment in quality and reliability. The power supply failures or fluctuations shall not cause the loss of data already recorded for trend displays. The SPDS load shall not degrade the capability or reliability of any safety related power source.

6.3.2 Control Room Display Requirements

6.3.2.1 Display formats must include pattern and coding techniques to assist operator's memory recall for detection and recognition of unsafe conditions.

6.3.2.2 The SPDS shall display pertinent information during steady state and transient condition.

6.3.2.3 Capability shall exist to present magnitude and trends as necessary to allow rapid assessment of the current plant status.

*Combined at Dresden/Quad Cities

6.3.2.4 Displayed variables shall be sufficient to indicate the status of the plant and shall be responsive to transient and accident sequences.

6.3.2.5 A summary display format consisting of the plant parameters from which the overall safety status of the plan may be depicted shall be provided.

6.3.2.6 The SPDS may consist of several secondary display formats in addition to the summary display. These formats shall be capable of random (operator selected) selection.

6.3.2.7 Operator interaction capability may be provided.

6.3.2.8 For all modes, a single primary display format consisting of principal process variable and where applicable their trends shall be routinely displayed from which the plant safety status may be inferred.

6.3.2.9 The SPDS may include other functions which aid operating personnel in evaluating plant status.

6.4 <u>Normal Value/Status of Primary Variables:</u> The normal, marginal and upset value(s)/status of the primary variables is a function of plant mode of operation, plant design and plant technical specifications. The SPDS Functional Description shall identify each primary variable's normal and upset value for all modes of plant operation.

6.4.1 The limits identified in Paragraph 6.4 shall be consistent, where practical, with existing plant alarm/trip points.

6.4.2 The limits shall be used to alert the operator to degrading condtions affecting the safety status of the plant.

6.4.3 The SPDS displays shall include the display of the primary variables status/value and the normal and upset values.

7.0 <u>References</u>

1. S. Levy, Inc. Report, SLI-8123, Rev. 1 "LaSalle Units I and II Safety Parameter Display System".
2. S. Levy, Inc. Report, SLI-8202, Rev. 0 "Quad Cities Units I and II Safety Parameter Display System".

1856L*

COMMONWEALTH EDISON CO.

LASALLE COUNTY STATION
SAFETY PARAMETER DISPLAY SYSTEM
FUNCTIONAL DESCRIPTION

1.0 Purpose

The purpose of the Safety Parameter display System (SPDS) is to provide to the reactor operator in a single location the value/status of primary variables which directly indicate the status of the safety parameters indicating the accomplishment or maintenance of plant safety functions. Plant safety functions are core cooling, reactivity control, reactor coolant system integrity, containment integrity, and radioactive effluents. The SPDS functions as an indicator only and it is intended that all SPDS readings be confirmed by the operator using existing control room instrumentation.

2.0 DEFINITIONS

The meaning of the words and terms, in context of their use in this specification, shall be in accordance with the following definitions.

2.1 Safety Parameter:

The safety parameter is defined to be the quantitative/qualitative or binary measure of accomplishment or maintenance of the safety functions identified in Paragraph 1.0.

2.2 Verification:

The verification is defined to be a procedure to obtain increased assurance that the indicated value represents the true value of a process variable.

2.3 Validation:

The validation is defined to be confirmation of the input signal to be within the range of the sensor/instrument.

2.4 Primary Variable:

The primary variables are defined to be the monitored variables that provide the most direct indication needed to assess the status/value of the safety parameter.

3.0 Description

3.1 Primary Display

The basic primary display format is shown in Figure 1. The display consists of three main sections.

3.1.1 Heading:

This section contains the display title, the station and unit being displayed, and the time of day.

3.1.2 Bar Graphs:

This section contains bar graphs for seven variables: reactor water level, reactor pressure, drywell pressure, drywell temperature, suppression pool level, suppression pool temperature, and reactor power. Associated with each bar graph is the variable name (below the graph), digital display of variable value, and digital display of rate of change and direction (increasing /decreasing) of the variable (both above the graph). The bar graphs are separated into three groups: Primary system variables, containment variables, and reactor power.

3.1.3 Status Boxes:

This section contains five boxes displaying the status of five variables/parameters: core spray system operation, safety relief valve positions, primary containment isolation, containment radiation, and radioactive release to the environment.

.2 Secondary Displays

No secondary displays exist at this time.

.3 Colors

3.3.1 Primary Display Colors

The following colors and associated functions are used on the SPDS primary color graphic display:

Cyan - Borders
Engineering Units
Digital values (invalid inputs)
Bar Graphs (invalid inputs)
Status Boxes (invalid inputs)
Scale Value Lines
Heading

White - Rate of change value
Digital Value (normal)
Time of Day

Green - Bar Graphs (normal)
Status Boxes (normal)
Normal Values and Value Lines

Yellow -Scale Values and Lines
Words in lower portion of status boxes.
Bar Graph Titles

Red - Alarm Value Lines
Bar Graphs (alarm)
Status Boxes (off normal)
Digital Valve (alarm)

4.0 Primary Display General Operation

4.1 Bar Graphs, Digital Values, Trends (Rate/Direction of change)

The seven bar graphs and digital values are composed points generated from multiple inputs. The inputs are sampled at five second intervals. The inputs are first validated by comparing the electronic input signal with the instrument range. Invalid (out of range) inputs may be used to verify the accuracy of valid inputs but are not displayed. Valid inputs are compared and/or combined to provide a verified, accurate value for the variable. This value is displayed as a digital value (top of bar graph) and as the relative height of the bar.

This verified value is also compared with the previous value and a direction and rate of change calculated and converted to units/minute and displayed and updated every five seconds.

If no valid inputs are available or a valid input is contradicted by other inputs, then the displayed variable is considered to be unverified and invalid. The SPDS will notify the operator of this condition.

Each bar graph is typically provided with a green bogey (expected value) line based on normal 100% power conditions and two red alarm lines (high and low) located at the alarm limits. Individual bar graph configurations are discussed later.

4.1.1 Digital Value Displays

The following changes are provided by the SPDS for the composed /calculated variable digital value displays:

Normal: Validated composed/calculated value within alarm limits displayed in WHITE.

Alarm: Validated composed/calcualted value above/below alarm limits displayed in FLASHING RED.

Acknowledged
Alarm: Validated composed/calculated value above/below alarm limits displayed in RED after alarm condition is acknowledged by the operator.

Invalid
inputs: Value displayed as CYAN ASTERISKS.

4.1.2 Trend Value displays

The following changes are provided by the SPDS for the composed/calculated variable trend value displays:

Normal: Calculated Trend Value and direction displayed in WHITE.

Alarm,
Acknowledged
Alarm: No change from normal conditions; no alarm conditions exist for trend values.

Invalid
Inputs: Trend value displayed as CYAN ASTERISKS.

4.1.3 Bar Graph Height and Color Changes

The height of the bar graph is proportional to the composed/calculated value of the variable and is accompanied by the following color changes:

Normal: Bar is displayed GREEN for values within the alarm limits.

Alarm: Bar is displayed FLASHING RED for values above/below alarm limits.

Acknowleged
Alarm: Bar is displyed RED for values above/below alarm limits after alarm is acknowledged by operator.

Invalid
Inputs: Bar is displayed FULL SCALE CYAN.

4.2 Status Boxes

The five status boxes indicate the normal/alarm condition of functions, components, or variables relating to the safety parameters. The input variables are validated and verified where possible as outlined in section 3.1. The inputs are then compared against pre-determined values or conditions to ascertain the normal or alarm status of the function, component, or varialbe being displayed. Abnormal or alarm conditions will cause the upper portion and outline of the box to change color from green to red. Loss of valid inputs will cause the color to change to cyan. Wording in the bottom of the box will change according to the status of the monitored function, component, or variables.

5.0 Safety Parameters and Associated Displays

5.1 Core Cooling

The adequacy of core cooling is assessed by measuring reactor water level and operation of the core spray systems (Reference 1). Verification of reactor water level to be above 2/3 core height is sufficient to ensure adequate core cooling. If water level indication is lost or level cannot be determined, verification of design flow rates in either the low pressure or high pressure core spray system is sufficient to ensure adequate core cooling.

5.1.1 Reactor Water Level

Reactor water level is indicated using the RX LEVEL bar graph with associated value and trend digital displays. The values displayed are a composite of the following water level inputs:

Upset Range (1 input)	0 to 180 inches
Narrow Range (2 inputs)	0 to 60 inches
Wide Rnage (4 inputs)	-150 to 60 inches
Fuel Zone Range (2 inputs)	-311 to -111 inches

The input signals are processed as shown in the block digram of Figure 2. The selection/combination of signals to be displayed is based on the following selection priority; considering the availability of valid/verified input values:

1. Narrow Range
2. Wide Range
3. Fuel Zone Range
4. Upset Range

The following values are indicated on the bar graph:

Bogey:	35 inches	(green line)
High Alarm:	54.5 inches	(red line)
Low Alarm:	12.5 inches	(red line)

5.1.2 Core Spray Operation

Core spray system operation is indicated using the CORE SPRAY ON (OFF) status box to alert the operator to off-normal operation. The inputs consist of high and low pressure systems flows and pump discharge pressures. The measured flows are verified by comparison with pump design flow/pressure characteristics using the discharge pressure inputs. Core spray demand is determined from reactor level and drywell pressure values. If a demand signal is present and neither the high nor the low pressure system are operating at or above design flow conditions (3500 gpm for HPCS and 6350 gpm for LPCS) the status box will indicate an alarm condition. At greater than 1000 gpm on either system the wording in the lower portion of the box will change to ON from OFF. Figure 3 is a block diagram of input processing.

5.2 Reactivity Control

Reactivity control is assessed by the measurement of reactor power level (Reference 1). The reactor power level is indicated using the RX POWER bar graph and associated digital value and trend displays. Inputs to the reactor power measurement are the six APRM's and four SRM's. If the APRM's are reading onscale in run or startup, they are used to determine power level; in shutdown and refuel when the APRM's are downscale the SRM's are used with preference given to SRM's which are inserted. Following a scram demand signal, an SRM reading above 10^5 or APRM's on scale could indicate a failure to scram. Figure 4 provides a block diagram of signal processing.

The following values are indicated on the bar graph:

Bogey:	100% power (green line)
High Alarm:	110% power (red line)
Low Alarm:	None provided

5.3 Reactor Coolant System Integrity

Maintenance of reactor coolant system integrity is assessed by the measurement of reactor pressure, drywell pressure, containment activity, safety/relief valve (SRV) positions, and isolation of PCIS valves in groups 1 and 2 (Reference 1). Rapid RPV depressurization, high drywell pressures, high containment activity, open SRV's, and open isolation paths all indicate actual or potential breaches of the reactor coolant system integrity. In addition, excessively high reactor pessure would cause SRV's to open and could potentially threaten the reactor coolant system physical boundary.

5.3.1 Reactor Pressure

Reactor pressure is indicated using the RX PRESS bar graph and associated digital value and trend displays. The four reactor pressure input signals are as follows:

Narrow Range (2)	850 - 1050 psig
Wide Range (2)	0 - 1500 psig

Valid signals are compared against each other and preferentially selected for display in the order listed above, if verified. Because of the increasing span in the ranges, this provides for the most accurate value. If only the last 2 wide range inputs can be verified, they are averaged. If none of the valid signals can be verified, the highest of the valid readings is selected (greatest potential threat to RCS integrity). The basic signal processing of Figure 5 is used for this display. The following values are indicated on the bar graph:

Bogey:	1000 psig (green line)
High Alarm:	1043 psig (red line)
Low Alarm:	None Provided

5.3.2 Drywell Pressure

Drywell pressure is indicated using the DW PRESS bar graph and associated digital value and trend displays. The three drywell pressure input signals are as follows:

Narrow range (2)	-5 to +5 psig
Wide range (1)	0 to 135 psig

Valid signals are compared for verification. If agreement is verified, the signals are averaged. Peference is given to the narrow range readings due to greater accurancy associated with the narrow spane. If signal agreement cannot be verified, the valid narrow range signal is selected, or the highest of disagreeing positive signals or the lowest of disagreeing negative signals. The basic signal processing of Figure 5 applies to the drywell pressure signals. The following values are indicated on the bar graph:

Bogey: 0 psig (green line)
High Alarm: 1.69 psig (red line)
Low Alarm: - 0.5 psig (red line)

5.3.3 Containment Activity

Containment activity is monitored using the CONTAIN RAD NORM (HIGH) status box to alert the operator to an obnormal operating condition. Two containment activity signals are used as inputs, each with a range of 1 R/hr to 10^8 R/hr. Valid signals are compared and averaged if in agreement or the highest signal selected if in disagreement. The basic signal processing of Figure 5 is used, except no value is displayed and only color changes are provided. The high alarm limit is 200 R/hr which is the GSEP Alert Emergency Action Level (EAL).

5.3.4 Safety Relief Valve (SRV) Positions

The position of the SRV's is monitored using the SRV CLOSED (OPEN) status box to alert the operator to an abnormal operating condition. Inputs to this indicator are the SRV position limit switches, reactor pressure from the SPDS, reactor level from the SPDS, drywell pressure from the SPDS, and low pressure ECCS pump discharge pressures. The demand for SRV pressure relief is determined from the reactor pressure value and the demand for ADS actuation is determined from the water level, drywell pressure, and low pressure ECCS pumps discharge pressure values. The valve position is then compared to the demand to determine any off-normal states, i.e. valves open with no signal present or valves closed when a signal is present. The signal processing of Figure 6 is used to determine the color and wording for this status box.

5.3.5 PCIS 1 and 2 Valve Positions

Reactor and containment isolation (groups 1 and 2 only) is monitored using the PCIS status box to alert the operator of a failure to isolate. Inputs to this indicator are the PCIS groups 1 and 2 valve position limit switches and group 1 and 2 isolation logic contacts. Valve positions are compared with the isolation demand signal and failure of all valves in any isolation path to close with an isolation signal present initiates an alarm state. Figure 6 provides the input processing used for this indicator.

5.4 Containment Integrity

Maintenace of containment integrity is assessed by the measurement of drywell pressure, drywell temperature, suppression pool level, suppression pool temperature, and containment isolation valve (groups 1 and 2) positions (Reference 1). Excessive drywell pressure, drywell temperature, and suppression pool temperature, and high or low suppression pool level indicate conditions which may violate containment design bases and potentially degrade containment integrity. Open isolation paths would indicate a breach of the containment boundary.

5.4.1 Drywell Pessure

See Section 5.3.2

5.4.2 Drywell Temperature

Drywell temperature is indicated using the DW TMP bar graph and associated digital value and trend displays. Three drywell average temperature inputs are used for this indication. The three signals are validated and then compared to verify accuracy. If signal agreement is verified, the signals are averaged. If no agreement is found between valid signals, the highest valid signal is selected for display. The basic signal processing of Figure 5 is used for this indicator. The following values are indicated on the bar graph.

Bogey: 125°F (green line)
High Alarm: 175°F (red line)
Low Alarm: 70°F (red line)

5.4.3 Suppression Pool Level

Suppression pool level is indicated using the SUPP LVL bar graph and associated digital value and trend displays. The three inputs to this indicator are as follow:

Narrow Range: -14 to + 14 inches
Wide Range (2): -18 to + 14 feet

Valid signals are compared for verification. Selection of the narrow range signal is preferred because of its accuracy. Wide range signals are averaged if in agreement, and where no agreement is found, the valid input with the greatest absolute valve (greatest deviation from 0) is selected. The basic signal processing of Figure 5 is used for this indication. The following values are indicated on the bar graph:

Bogey: 0" (green line)
High Alarm: +3" (red line)
Low Alarm: -4.5" (red line)

5.4.4 Suppression Pool Temperature

Suppression Pool Temperature is monitored using the SUPP TMP bar graph and associated digital value and trend displays. Fourteen local temperature sensors provide inputs for this indicator. All valid signals are averaged for this value, using the basic signal processing of Figure 5. The following values are indicated an the bar graph:

Bogey: 85°F (green line)
High Alarm: 105°F (red line)
Low Alarm: None Provided

5.4.5 PCIS 1 and 2 Valve positions

See section 5.3.5

5.5 Radioactive Effluents

Radioactive effluents are assessed by the measurement of radiation levels or release rates at the gaseous and liquid release points (Reference 1). Excessive releases or radiation levels are indicated using the RAD RELEASE NORM (HIGH) status box.

Inputs to the radioactive release status box came from the offgas pretreatment log rad monitor; SBGT and main chimney rad monitors; SBGT and main chimney flow meters; and the liquid radwaste, service water discharge, and RHR loops A and B discharge rad monitors.

Although the offgas system at the monitor location does not provide a direct path to the environment, high radiation at this point would indicate degradation of a fission product barrier and the potential for a radioactive release.

Validation (signal within instrument range) is performed on all signals. The liquid pathway and offgas monitors are single instruments and no signal verification can be performed. The same is true for the SBGT and main chimney flow sensors.

The SBGT and main chimney radiation monitors consist of three instruments each with overlapping ranges. If two of three signals agree, the one with the lowest range is chosen for greater accuracy. Where no agreement exists, the lowest range reading is chosen. This signal is then combined with a measured flow rate to produce a release rate. The sum of the SBGT and main chimney release rates is compared to the high alarm limit. The basic signal processing of Figure 5 is used for each effluent path. If the value for any effluent path exceeds the alarm point or has no valid inputs, the status box color will change to RED or CYAN, respectively. The following is a list of inputs for each effluent path:

Off Gas - Pretreatment monitor, 1 to 1×10^6 mR/hr

SBGT Radiation - Low Range, 10^{-7} to 10^{-1} uCi/cc
- Mid Range, 1.2×10^{-4} to 1.2×10^2 uCI/cc
- High Range, 10^{-1} to 10^5 uCi/cc

SBGT FLow - flow element 1Ft-VG003 0-5000 CFM

Main Chimney Radiation-Same as SBGT Radiation.

Main Chimney Flow - Flow element OFT-VR019, 0-1.5×10^6 CFM

Liquid Radwaste - Discharge Monitor, 10 to 10^6 CPM

Plant Service Water - Discharge Monitor, 10 to 10^6 CPM

RHR Loop "A" - Discharge Monitor, 10 to 10^6 CPM

RHR Loop "B" - Discharge Monitor, 10 to 10^6 CPM

The high alarm limits for the various paths are as follows, and are based on existing high alarm limits or GSEP Alert condition EAL's:

Off Gas, 1×10^4 MR/hr (existing alarm point)
SBGT plus Main Chimney, 1.22×10^7 uCi/sec (Alert EAL)
Liquid Radwaste, 1.5×10^4 cpm (Alert EAL, 2X bkgd.)
Service Water, RHR "A", and RHR "B", 400 cpm (Alert EAL)

6.0 Alarms and Messages

6.1 Audible Alarms

6.1.1 Deviations from Normal

The following changes from a normal status will activate the computer alarm horn:

Composed point or status box exceeding high/low alarm point
Composed point or status box has invalid inputs

6.1.2 Return to Normal

The computer alarm chime will activate whenever a composed point or status box in the alarm or invalid state returns to a normal condition.

6.2 Error Messages

6.2.1 Deviation from Normal

Associated with the alarms identified in 6.1.1 above is an alarm message which appears in red print on the computer alarm typer. The message identifies the alarm as being associated with the SPDS and identifies which composed point has exceeded its alarm limit or is out of range.

6.2.2 Return to Normal

Following the return to normal of composed points or inputs, the computer alarm typer will print in black a message identifying the SPDS point and that it has returned to the normal state.

7.0 References

1. "Commonwealth Edison Co. Dresden, Quad Cities, LaSalle Safety Parameter Display System Function Specification", Rev. 1 dated 2-16-83.

0939a*:dg

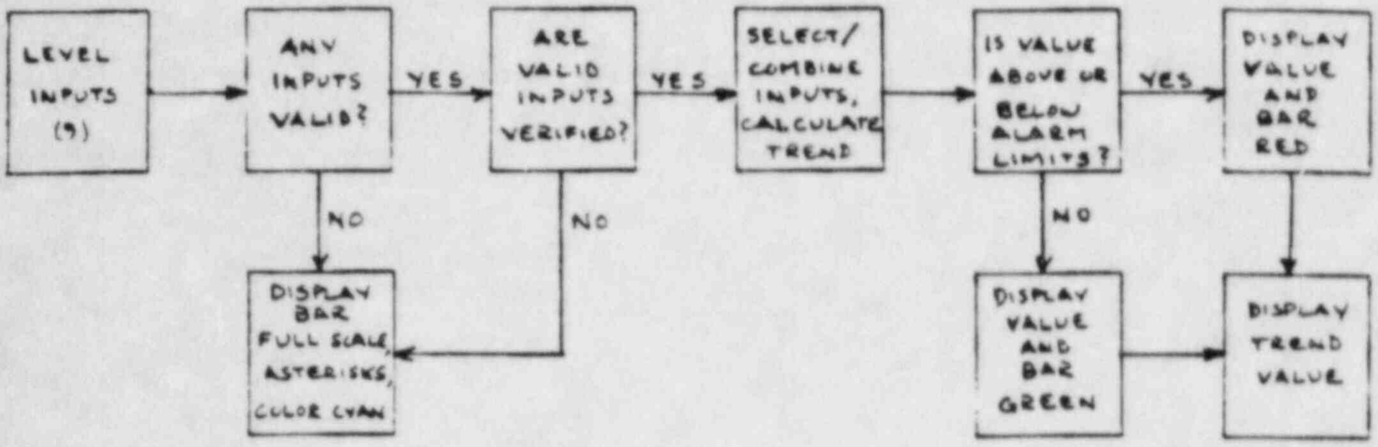

FIGURE 2

REACTOR WATER LEVEL SIGNAL PROCESSING

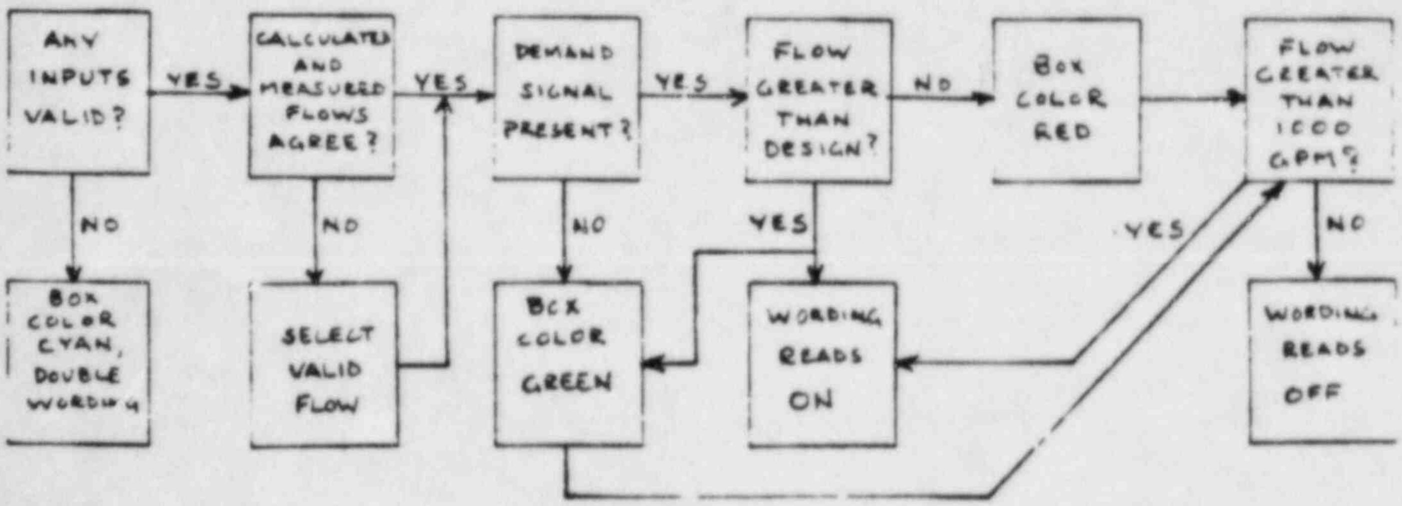

FIGURE 3

CORE SPRAY SIGNAL PROCESSING

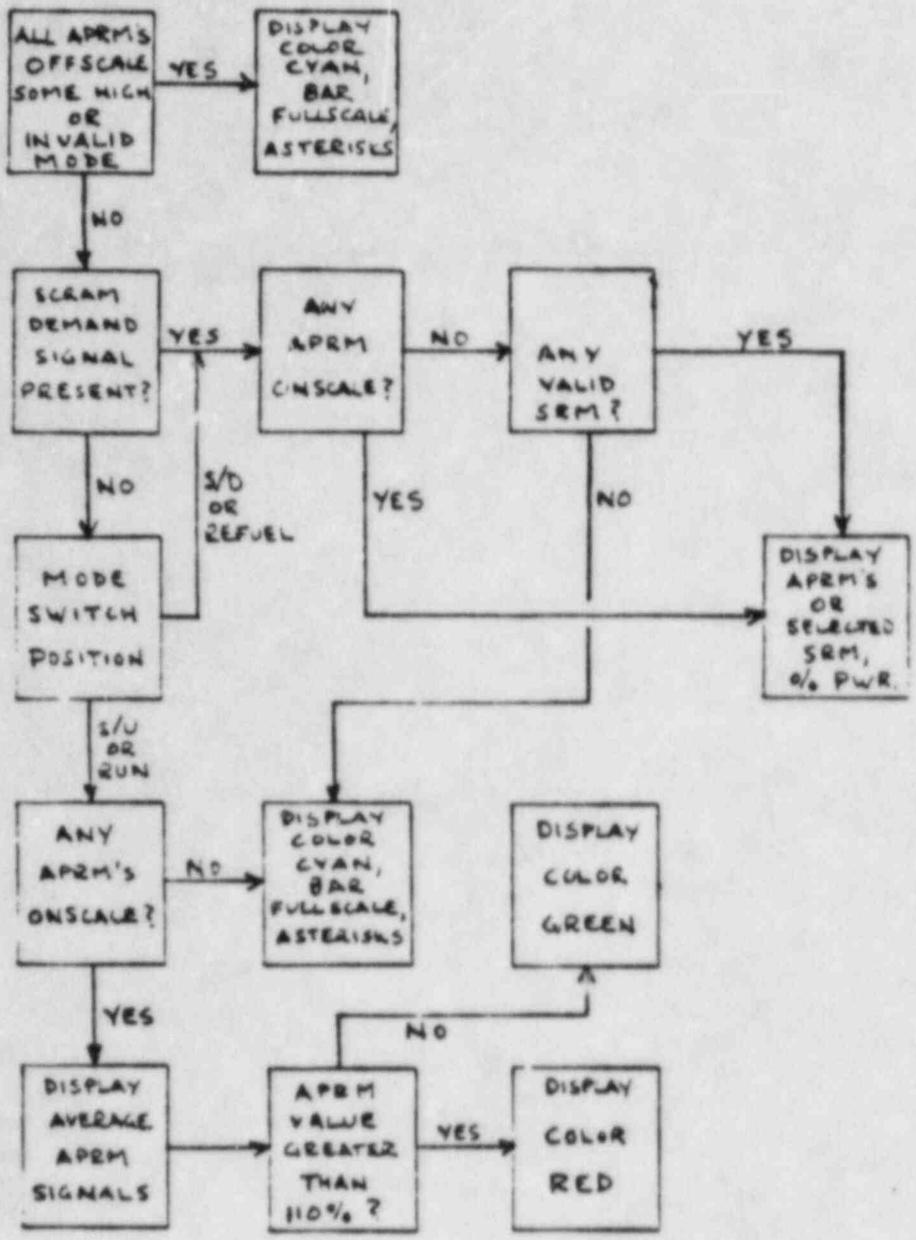

FIGURE 4

REACTOR POWER SIGNAL PROCESSING

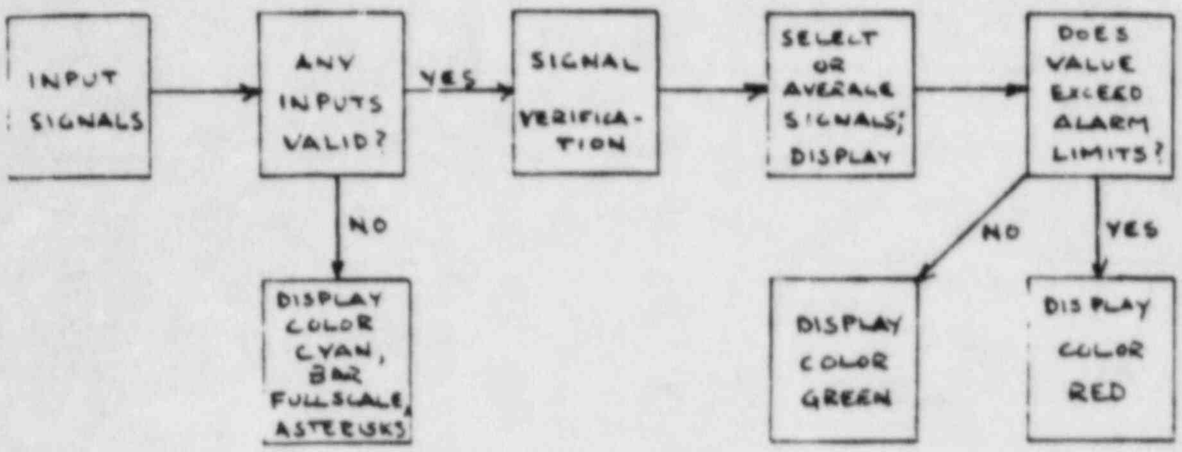

FIGURE 5

BASIC SIGNAL PROCESSING

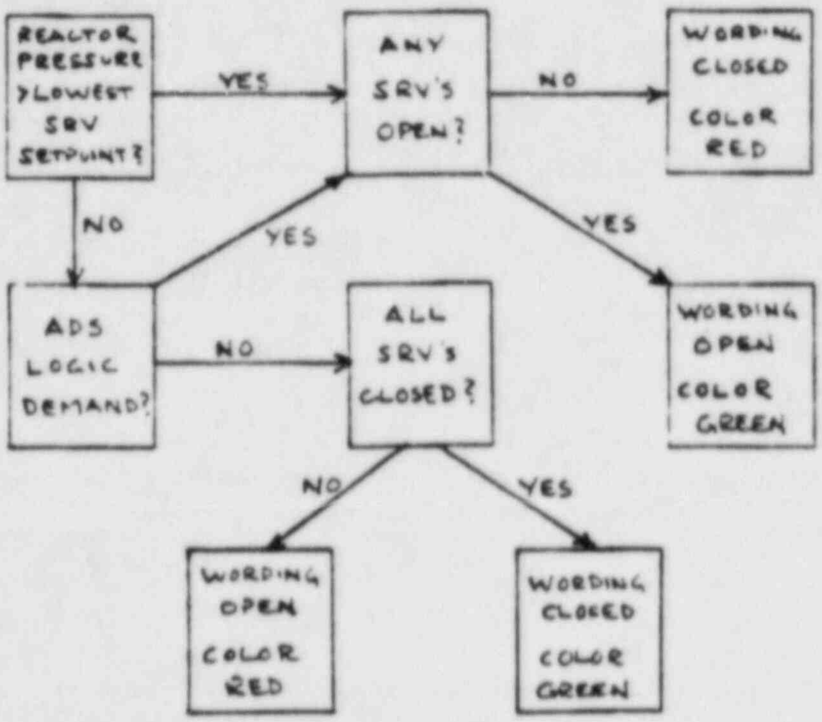

FIGURE 6

SRV SIGNAL PROCESSING

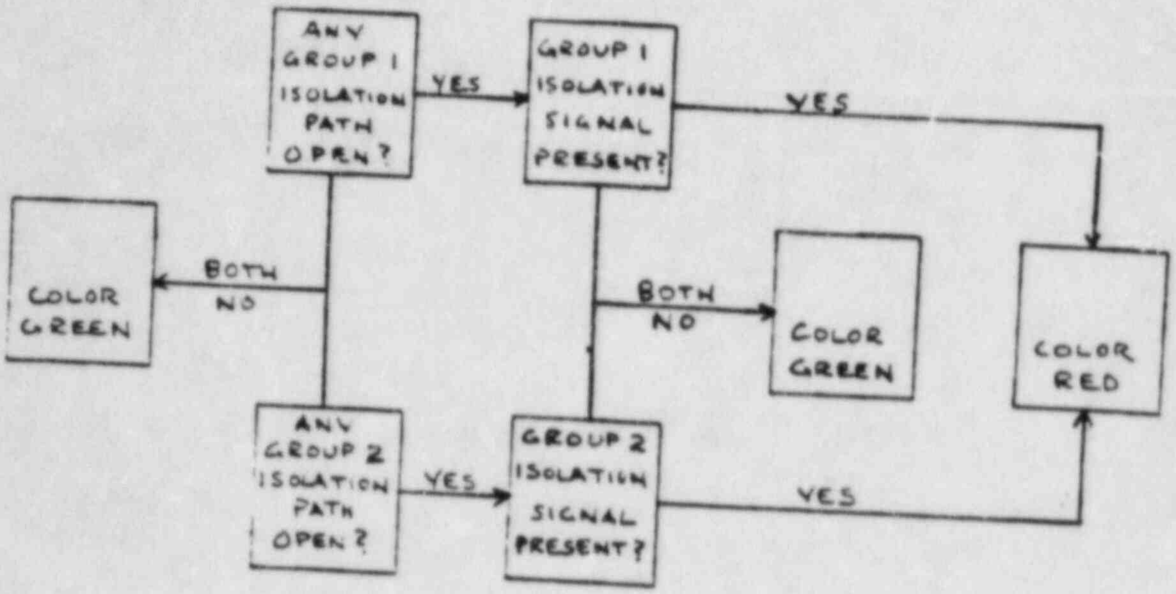

FIGURE 7

PCIS SIGNAL PROCESSING

ATTACHMENT D

SPDS DISPLAY SYSTEM OPERATING SYSTEM PROCEDURE

SPDS DISPLAY SYSTEM

A. PURPOSE

This procedure explains the function of and operator response to the Safety Parameter Display System (SPDS).

B. REFERENCES

1. None.

C. PREREQUISITES

1. None.

D. PRECAUTIONS

1. The SPDS Display is not intended to provide sufficient indication to justify direct operator action on reactor or auxiliary system controls. The operator should refer to additional panel indications and alarms to confirm system status before taking action in respone to an SPDS System Alarm.

E. LIMITATIONS AND ACTIONS

1. The SPDS system is a program contained in the process computer designed to provide a composite visual indication of several vital plant operating parameters.

2. Bar Graphs and digital readouts displayed by SPDS are normally colored green. A change to blue color indicates that the required number of instrumentation channels are not operable. And red bars and digits indicate parameters in alarm condition.

F. PROCEDURE

1. A green display indicates operationg conditions are in the normal range. However, if parameter valves disagree seriously with other panel indication, the Shift Supervisor and Technical Staff Computer Group should be notified of the disagreement.

2. A blue display indicates an insufficient number of operable instrument channels for a given parameter. The Shift Superviser and Technical Staff Computer

Group should be notified of this condition. Initiation of a Work Request may be applicable.

3. A flashing red display indicates that a parmaeter has exceeded an alarm setpoint. The operator should:

   a. ACKNOWLEDGE the alarm by depressing the ALARM ACKNOWLEDGE button on the Operator's console of the process computer. The display may take a few seconds to respond to acknowledgement before the display will assume a solid red color. Alarmed parameters will automatically change back to the green color when parameter inputs fall back to within normal ranges.

   b. CHECK panel indications and alarms for verification of SPDS alarm condition.

   c. RESPOND to the alarm condition using approved procedures, if the alarm condition proves valid.

G. CHECKLISTS

   1. None.

H. TECHNICAL SPECIFICATION REFERENCES

   1. None.