OYSTER CREEK

SPDS Parameter Selection / Safety Analysis Study

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SUMMARY

A Critical Safety Functions (CSF) approach was used as the basis for a Safety Parameter Display System and five CSFs were chosen that correlate with the basic objectives of Emergency Operating Procedures. A parameter set was then selected largely based on EOPs parameters and the Emergency Plan radiation monitoring parameters (ARMS). Groups of parameters were then assigned to the different CSFs based on plant operating and emergency procedures logic. These safety functions were then activated to warning or alarm modes using different setpoints that are used by the different procedures. The CSFs were then tested on a broad range of transient scenarios to check their response. The final parameter list (Table 3.1) responded to every manual or automatic action that was required to be taken during these scenarios. It is therefore believed that the CSFs and the parameter set chosen form a complete set that should respond to plant conditions during power operation and shutdown modes.

This represents the system's conceptual design which will be updated to reflect evolution of actual design when instruments to be used have been determined.

1.0 INTRODUCTION

NUREG-0737 Supplement 1, Section 4.0 requires the incorporation in the control room of a Safety Parameter Display System to aid the user in assessing plant safety status. A spectrum of opinion exists as to what plant safety status means. The BWROG position is to integrate SPDS with Emergency Operating Procedures (EOPS) resulting in a computerized EOPS system where EOPS steps are displayed for the user to follow, with certain parameter trends, and systems status shown as an aid for proper EOPS implementation[1]. This approach would limit the usefulness of SPDS to emergency situations and would not add any new information which is not immediately available on the control panels or in the procedures and easily accessible. Another opinion that was discussed was to use SPDS in addition to EOPS, as a display terminal where important plant conditions are shown or trended. In this manner it will only be used by control room supervisors as an overview function. This approach would lead to a computerized control room display with the user still having to resolve the interdependence of plant parameters and make judgment as to the safety status of the plant. Another opinion was to limit SPDS to supply information which is not easily accessible to the user, like level rate of change, torus limit curves etc. After careful review, we have adopted the concept of Critical Safety Functions (CSFs) where a CSF is a measure of the safety status of a group of plant parameters which together convey a coherent meaning with regard to plant safety. These CSFs are also supported by a set of displays that would convey a concise picture of plant

conditions where the affected safety function is concerned. The CSF approach is followed here because it focuses attention on that aspect of plant safety where a response is most urgently needed.

The following requirements were followed in this study:

1. A minimum set of parameters must be chosen that would uniquely describe a certain CSF under all plant conditions (during power, emergency and shutdown modes).
2. The SPDS will assist in EOPs implementation by identifying EOPs entrance criteria and displaying parameters, trends and limits which are included in the plant emergency procedures.
3. Displays to be generated would have to concisely reflect plant status showing without ambiguity the interactions between the different parameters that form each CSF.
4. Users' guidelines which would supplement existing procedures must be generated.

The basis SPDS is an overview tool to be used by the GSS, GOS, or STA. It should be noted that control room operating personnel may have additional displays tailored to their needs to assist them in following the symptom based EOPs. These additional displays will be supportive of the critical safety functions. The SPDS is to be provided as an aid for use at the discretion of the GSS, GOS or STA. In no cases is its use mandatory for safe operation.

2.0 LITERATURE REVIEW

The available literature on this subject is related to the time period before the release of NUREG-0737 Supplement 1 on December 17, 1982. The purpose of this review is to highlight the basic methodologies used and how they compare with the approach used here.

S. Levy Inc. carried out a parameter selection study for a generic BWR[2]. Their recommended critical safety functions and the parameter set are shown in Table 2.1.

The basic arguments used in this selection were concerned with:

- Parameter duplication;
- Loss of the parameter during an accident, e.g. steam flow is lost upon vessel isolation;
- Degree of interaction between the different parameters, i.e. whether a safety function status can be inferred from a parameter used for another safety function.

NUTAC[3] presented a different set of CSFs and parameters for a hypothetical BWR (Table 2.2). Here the reactivity CSF has been included as part of core cooling and heat production CSF. These two references were the only ones found in the literature that present a set of CSFs and their respective parameters for a BWR.

NUREG-0737 Supplement 1, Section 4.0 requires information to be provided to the user on:

- Reactivity Control
- Reactor Core Cooling and Heat Removal from the Primary System
- Reactor Coolant System Integrity
- Radioactivity Control
- Containment Conditions

The above NRC functions were used as guidelines in generating Oyster Creek CSFs.

TABLE 2-1

RECOMMENDED FUNDAMENTAL SAFETY PARAMETER SET FOR

A BOILING WATER REACTOR (S. Levy)

Safety Function Monitored	Parameter
Containment of Radioactivity (Radioactivity Release Control)	Plant Ventilation Monitor
	Main Stack Monitor
	Primary Coolant System Activity
	Primary Containment Activity
Fission Product Barrier Integrity	Plant Ventilation Monitor*
	Primary Coolant System Activity*
	Drywell Floor Drain Sump
	Drywell Pressure
	Primary Coolant System Pressure
	Primary Coolant System Water Level
	Safety/Relief Valve Positions
	Leakage Isolation Demand
	Suppression Pool Level
	Hydrogen Concentration
	Secondary Containment Pressure
	Primary Containment Activity*
Heat Transport	Primary Coolant System Pressure*
	Primary Coolant System Water Level*
	Suppression pool Level*
	Drywell Temperature
	Average Power Range Monitor
	Core Flow
	Suppression Pool Temperature
Reactivity Control	Average Power Range Monitor*
	Source Range Monitor
	Source Range Monitor Position
	Scram Demand Signal
	Mode Switch Position

* Repeated Parameter

TABLE 2.2

HYPOTHETICAL BWR CSF STATUS PARAMETERS (NUTAC)

Critical Safety Function	Associated SPDS Parameters
Containment of Radioactivity	Plant Ventilation Monitors Main Stack Monitor
Primary Coolant System Integrity	Drywell Floor Drain Sump Drywell Pressure Primary Coolant System Pressure Primary Coolant System Water Level Safety Relief Valve Positions
Containment Integrity	Drywell Pressure Primary Coolant System Pressure Suppression Pool Level Secondary Containment Pressure Drywell Temperature Suppression Pool Temperature
Core Cooling and Heat Production	Primary Coolant System Pressure Primary Coolant System Water Level Core Spray Flow Core Flow Average Power Range Monitor Intermediate Range Monitor Source Range Monitor

3.0 SPDS PARAMETER IDENTIFICATION

The first step in the identification process was to define a set of Critical Safety Functions (CSFS) that will convey to the user the plant safety status and at the same time satisfy NUREG-0737 Supplement 1 Section 4.0, main safety categories. The second step was to select plant parameters that are consistent with EOPs and that will reflect the status of each critical safety function. The third step will be to generate a users' guideline that would aid in evaluating and dealing with abnormal conditions. These guidelines would then serve as the basis for developing displays and for training users in the use of SPDS. The first two steps are discussed herein.

3.1 Critical Safety Functions

The CSFS chosen for Oyster Creek and their sub-divisions are:

1. Reactivity / Power Distribution
2. Heat Removal
    - Fuel clad cooling
    - Primary system cooling
3. Reactor Coolant System Integrity
    - Fuel integrity
    - Primary system integrity
4. Radioactivity Control
5. Containment Conditions

3.2 Parameter Selection

Each CSF will be discussed separately. Emergency Operating Procedures parameters will be selected that best reflect the status of each CSF. This approach would make sure that EOPS parameters are tied into the SPDS. The overall SPDS logic will switch from 'AT POWER' to 'SHUTDOWN' logic upon a scram demand.

3.2.1 Reactivity / Power Distribution

When the plant is at steady state power operation the Reactivity Control CSF will monitor for power peaking and core thermal limits. Since power peaking and thermal limits are not directly measurable, they will be monitored by using other parameters that will then bound the power peaking and thermal limits concerns.

During all modes, the core startup rate will be monitored to determine gross reactivity concerns.

Reactor power will also be monitored during power operation and post trip to determine if an ATWS or power excursion has occurred.

The required parameters are:

° Neutron Flux

° Scram Demand

° Recirculation Flow

3.2.2 Heat Removal

The basic parameters of heat transfer are mass flow, power, pressure and temperature. Once heat balance is violated, this CSF will provide warning and alarm.

3.2.2.1 Fuel Clad Cooling

Fuel clad temperature is the desired parameter but since it is not available, RPV level may be used as an alternative parameter under certain conditions. Other candidate parameters are core mass flow (recirculation flow) and power (Neutron Flux).

During normal operation core flow and power are the required parameters while during shutdown vessel level (downcomer and fuel zone levels) and core spray discharge pressure are the required parameters.

Total Parameters are:

- ° RPV level
- ° Recirculation Flow
- ° Neutron Flux
- ° Scram Demand
- ° Core Spray Discharge Pressure

Core spray flow may be used instead of discharge pressure. This will be decided during design evolution when instruments to be used are determined.

3.2.2.2 Primary System Cooling

This index will measure the adequacy of the primary system as a heat removal medium. At shutdown, if fuel clad cooling is assured, then RPV level and pressure are the main parameters required. If RPV pressure is above relief valves or emergency condenser setpoints (on RPV isolation), or if RPV level is at low-low (Emergency Condenser setpoint), then adequate heat removal may not be provided. While at power, steam flow and feed flow are the required parameters for proper heat removal. RPV isolation which might be caused by a number of signals is represented by an isolation demand parameter. This parameter together with steam flow are required to monitor the status of the main condenser as a heat sink, i.e. if isolation demand is present while steam flow is still available then user action is required to prevent using the condenser as a heat sink. Steam flow at power may be used as a backup parameter for heat balance representation.

Required Parameters are:

- RPV Level
- RPV Pressure
- Steam Flow
- Feed Flow
- Isolation Demand
- Neutron Flux

3.2.3 Reactor Coolant System Integrity

3.2.3.1 Fuel Integrity

If fuel clad integrity is violated during normal operation, the steam line radiation monitor will detect it. Such monitoring may induce the user to take action before further breach takes place since this monitor is quite sensitive to fuel failure. If steamline radiation monitors fail to detect it, the stack offgas monitors will provide detection.

If fuel failure happens after vessel isolation, the radioactive fission products (and hydrogen) will find their way to the drywell where they will be detected by drywell area radiation monitors (ARMS). Therefore, required parameters are:

- Steam line radiation monitor
- Drywell activity monitor
- Offgas monitor (stack)
- Combustible gases

3.2.3.2 Primary System Integrity

This will be divided intc that portion of the system within the primary containment and the portion outside.

Within primary containment: For very small breaks inside the drywell, the uncontrolled sump pump out rate, steam flow and feed flow will be required. For larger breaks, drywell pressure, torus pressure, RPV level and pressure are the required parameters. The addition of a drywell level indicator is being evaluated in conjunction with RG 1.97 requirements. If in the future a drywell level indicator is made available, it will be added and used as an indicating parameter.

Outside the primary containment: Breaks outside the containment will be detected by isolation demand and ventilation radiation monitors where leakage of radioactivity will be detected.

Therefore, required parameters are:

- Scram demand
- Drywell pressure
- RPV level
- Steam flow
- Torus pressure

- Uncontrolled sump pump out rate
- Isolation demand
- Turbine/Reactor buildings ventilation monitors
- Feed Flow

Steam flow is required to detect main steam line breaks (causing vessel isolation) while feed flow is required since it is the first inventory make up source used. These parameters may also be useful in detecting small breaks, i.e. relief valve leaks to the torus. Isolation demand is needed to set up the algorithms that would differentiate and prioritize monitoring the different CSFs, i.e. if isolation demand and high drywell pressure are present then containment isolation has taken place and the containment integrity CSF has to be monitored on a priority basis, in conjunction with other challenged CSFs.

3.2.4 Radioactivity Control

In general, radioactivity would come about in two forms:

- Gaseous activity
- Area activity (contamination)

Gaseous activity will show up through the ventilation systems, therefore, the required parameters are:

- Stack vent monitor
- Turbine/Reactor buildings ventilation systems radiation monitors

Area contamination is measured by the area radiation monitors. The relevant monitors have been chosen and are provided in Table 3.2.

3.2.5 Containment Conditions

The conditions of concern are containment cooling and containment integrity.

3.2.5.1 Containment

The heat paths into and out of the containment are:

Torus

1. EMRVs discharge
2. Heat storage in pool inventory
3. Heat removal through containment spray in test mode
4. Drywell/Torus vents

Drywell

1. SVs discharge
2. Normal heating from vessel structure
3. Heat removal through containment spray
4. Heat removal through drywell coolers
5. Leaks/rupture

Torus conditions above can be monitored through torus water level and temperature. RPV pressure is also required to guard against the onset of unstable steam condensation in the pool. Torus temperature and level limit curves are required to initiate alarms and warnings once these limits are reached. Drywell conditions above are monitored through drywell pressure and temperature.

Required parameters are:

- o Torus Level
- o RPV Pressure
- o Drywell Pressure
- o Drywell Temperature (bulk and axial distribution)
- o Torus Temperature

3.2.5.2 Primary Containment Integrity

Drywell: Monitoring drywell pressure, both positive and negative and isolation demand will detect an approach toward design limits. Combustible gases concentration is also required since hydrogen oxygen combustion may result in drywell integrity violation. Drywell pressure setpoint should be a function of drywell design limits.
Torus: Torus water level is the required parameter for leak detection below the operating level. However, torus water temperature is also required since a leak during torus heat up may be masked by water expansion.

In such cases, area radiation monitors in the reactor building will be required for such detection since water activity during EMRVs discharge will increase. Torus air space pressure is required to monitor the status of the vacuum breakers and hence, the integrity of the ring header/vent pipes. For cases where drywell pressure equals torus pressure, then torus design pressure becomes limiting.

The required parameters are:

- Drywell pressure (function of structural limits)
- Isolation Demand
- Combustible gases
- Torus water level
- Torus temperature
- Torus air space pressure
- Radiation monitors (Table 3.2)

Table 3.1 shows the Critical Safety Functions - Parameters Matrix. The setpoints required to initiate various CSFs and the logic to be used will be investigated later. User actions as a result of CSF initiation will be discussed when CSFs initiation logic is fully investigated.

3.3 CSFS and EOPS

The CSFS should be compatible with EOPS objectives. EOPS objectives are to control power, level, pressure and containment conditions. Power is correlated with the Reactivity CSF while level is correlated with the Heat Removal CSF, which is further divided into Fuel Clad Cooling and Primary System Cooling. The two subdivisions were used to highlight the importance of fuel clad cooling requirements and primary system cooling requirements. Maintaining the latter will avoid getting into the former. Containment Conditions is a separate CSF which includes Containment Cooling and Containment Integrity.

A Separate Radioactivity Control Safety Function was chosen to supplement EOPS. Control of radioactivity is not dealt with explicitly in the EOPS, but CSFS guidelines for radioactivity will be written to be consistent with EOPS. EOPS figures and limits will also be considered in development of SPDS displays and setpoints. It is therefore concluded that the chosen CSFS encompass the basic objectives of the EOPS in maintaining proper plant conditions.

All chosen parameters are EOP parameters except:

- Drywell Activity Monitors
- Reactor/Turbine buildings ventilation monitors
- Combustible gases monitors
- Area radiation monitors (ARMS) shown in Table 3.2
- Uncontrolled Drywell Sump level monitor
- Drywell Axial temperature monitors

The list of ARMS was chosen in accordance with Emergency Plan requirements. A number of EOPS parameters have not been included in the list since those parameters are used to check the status of various systems, e.g. valves and pumps status for systems line ups, etc. None of those parameters are the primary indicators of plant safety.

Parameter	REACTIVITY	FUEL CLAD COOLING	PRIMARY SYSTEM COOLING	FUEL CLAD INTEGRITY	PRIMARY SYSTEM INTEGRITY	CONTAINMENT COOLING	CONTAINMENT INTEGRITY	RADIOACTIVITY
1. NEUTRON FLUX	X	X	X					
2. SCRAM DEMAND	X	X			X			
3. RPV LEVEL		X	X		X			
4. RPV PRESSURE			X			X		
5. RECIRCULATION FLOW	X	X						
6. DRYWELL PRESSURE					X	X	X	
7. DRYWELL TEMPERATURE (BULK & AXIAL)						X		
8. TORUS WATER LEVEL						X	X	
9. TORUS TEMPERATURE						X	X	
10. TORUS AIR SPACE PRESSURE					X		X	
11. STEAM LINE RADIATION MONITOR				X				
12. DRYWELL ACTIVITY				X				
13. STACK ACTIVITY				X				X
14. TURBINE/REACTOR BUILDINGS VENTILL MONITORS					X			X
15. DRYWELL SUMP (UNCONTROLLED)					X			
16. COMBUSTIBLE GASES				X			X	
17. AREA RADIATION MONITORS							X	X
18. STEAM FLOW			X		X			
19. FEED FLOW			X		X			
20. ISOLATION DEMAND			X		X		X	
21. CORE SPRAY DISCHARGE PRESSURE		X						

TABLE 3.1: SPDS CSFS - Parameters Matrix

TABLE 3.2

AREA RADIATION MONITORS

1. Admin. Bldg. to Turb. Bldg. N. Entrance
2. Turb. Oper. Fl.
3. Feed Pump Area (T.B.)
4. Feed Pump area (T.B.)
5. Cond. Pump (above pumps, T.B.)
6. Cond. Demin. Valve (T.B. Bsmt)
7. Regeneration Area
8. Make up Demin. (T.B. Bsmt)
9. Air Compressors (T.B. Bsmt)
10. T.I.P. Equip. Area (R.B.)
11. Personnel Lock
12. RX. Oper. Floor (Eq. Hatch area)
13. RB Eq. Drain tank
14. Cleanup pump area (RB)
15. Iso. Cond. Area
16. Shutdown Cooling Area
17. Spent Fuel Pool (RB. 95'-3")
18. Liq. Poison Syst. (95'-3")
19. CRD modules area (RB, 23'-6")
20. Air Ejectors (T.B. 3'-6")
21. Fuel Pool Area (119')

3.4 Comparison with Other Parameter Sets

In order to compare Oyster Creek CSFs parameters set with those of S. Levy and NUTAC, Table 3.1 has been re-arranged in terms of the main four CSFs and put in the same format as Tables 2.1, 2.2 (Table 3.3).

1. Containment of Radioactivity: The first two parameters are common to all lists. The area radiation monitors have been added as part of the ERF coordination with SPDS as stated in NUREG-0737 Supplement 1, Section 3.4.d. The ARMS list was taken from the Emergency Plan. Primary coolant activity monitors (not available and will not be installed in accordance with BWROG position on RG 1.97) and drywell activity monitors (not available but will be installed as part of RG 1.97 compliance) were not included here as compared to Table 2.1 (S. Levy) because this CSF has been limited to controlling radioactive release outside the primary containment.
2. RCS Integrity/Containment Conditions: The parameter list of these CSFs is more comprehensive than either of those in Tables 2.1, 2.2. The main differences are the inclusion of torus air space pressure, steam line monitor and ARMS. The first two were included since they are important EOPs parameters while the last one is a useful parameter for area contamination detection due to pipe breaks. The safety/relief valve position are missing from the OC list since it is felt that the operation of these valves can be inferred from RPV pressure, drywell pressure and torus temperature. Secondary containment pressure was not regarded as a useful parameter since the ARMS are better indicators of the secondary containment integrity.

3. Heat Removal: Again the Oyster Creek list is more comprehensive than either of the other lists. The inclusion of steam flow and feed flow was thought to be important since a wide range of scenarios exist where those parameters are the best indicators of heat removal from the vessel. Core spray discharge pressure was included as compared to core spray flow (this may change to core flow when instruments are chosen).

4. Reactivity/Power Distribution: The same parameters are used as in Table 2.1 except for recirculation flow instead of the mode switch since the operation modes for Oyster Creek SPDS are AT POWER and SHUTDOWN.

Using the SRMs for post shutdown reactivity monitoring was not considered to be beneficial since once the APRMs are below 2% after a scram demand (EOPs criterion for shutdown) enough negative reactivity has been inserted to prevent a criticality concern during any acceptable time frame. Also, plant procedures require control rod positions to be checked after a scram for partially inserted rods.

TABLE 3.3

OYSTER CREEK SAFETY PARAMETER SET

Safety Function	Parameter
Radioactivity Control	Stack Monitor Plant Ventilation Monitors Area Radiation Monitors
Reactor Coolant System Integrity	Steam Line Radiation Monitor Drywell Activity Monitors Stack Monitor Combustible Gases RPV Level Drywell Pressure Plant Ventilation Monitors Drywell Sump (Uncontrolled) Steam Flow Isolation Demand Torus Air Space Pressure Feed Flow Scram Demand
Heat Removal	Neutron Flux Scram Demand RPV Level Recirculation Flow RPV Pressure Steam Flow Feed Flow Isolation Demand Core Spray Discharge Pressure (or core spray flow)
Reactivity/Power Distribution	Neutron Flux Scram Demand Recirculation Flow
Containment Conditions	Drywell Pressure Drywell Temperature Torus Level Torus Temperature Isolation Demand Combustible Gases RPV Pressure Torus Air Space Pressure Area Radiation Monitors

4.0 RESPONSE TO TRANSIENTS/ACCIDENTS

A broad range of transients/accidents were analyzed and tested against the SPDS parameter list. The purpose of these tests was to see if each event in a transient can be adequately monitored and evaluated by the SPDS parameter list (Table 3.1). The Oyster Creek Probabilistic Safety Analysis[4] (OPSA) transients and others were used for this purpose.

The list of transient/accident scenarios that were analyzed is shown in Table 4.1. An example of SPDS response to a LOCA is presented below. This was chosen for its simplicity as an example but much more elaborate event sequences were analyzed [5].

4.1 Large/Intermediate Break Below the Core Inside Containment

An example of this type of break would be a recirculation line break or a break in any connected piping to the recirculation system below the core. This break is large enough to result in rapid depressurization of the reactor vessel which allows core spray injection without the assistance of the automatic depressurization system. Core spray injection is the only viable means of core cooling for this type of break since the reactor core cannot be reflooded due to the break size below the core. In addition, a reactor scram is not required to bring the core to a subcritical state because the reactor core is not reflooded. Break sizes with an effective total leak area of 0.5 square feet or more fall into this category. All transfers to the core damage state assume there is water on the reactor cavity floor. All breaks that meet the above criteria are categorized as initiating event L1.

4.1.1 Event Sequence Diagram L1

The "Large/Intermediate Break Below the Core Inside Containment" event sequence diagram is shown in Figure 4.2 and described below.

4.1.2 Reactor Vessel Internals Remain Coolable (Event VC)

Event VC is the core fuel and other reactor vessel internals remaining in a coolable geometry due to the hydrodynamic and differential pressure loadings of the blowdown. Failure of event VC is assumed to result in an early, low pressure core damage state. SPDS monitoring of this event is done through RPV level, area and drywell radioactivity monitoring, vessel pressure, containment temperature and pressure.

4.1.3 Suppression Pool Integrity Maintained (Event SP)

Event SP is maintaining suppression pool structural integrity as a result of the hydrodynamic loads from the blowdown so that it can be used as a water source for core spray and containment spray operation. Failure of event SP is assumed to result in an early, low pressure core damage state since the water source is lost and the containment is failed. Suppression pool air space pressure, pool temperature, drywell pressure and temperature are SPDS parameters used to monitor SP integrity.

4.1.4 Core Spray Injection (Event CS)

Event CS is actuation of at least one train of the core spray system on low-low reactor vessel water level or high drywell pressure and injection of torus water into the reactor vessel after the vessel pressure drops below 285 psig. Failure of event CS is assumed to result in an early, low pressure core damage state. Suppression pool temperature, vessel level and core spray discharge pressure are used by SPDS for this event.

4.1.5 Containment Sprays & Suppression Pool Cooling (Event DS)

Event DS is actuation of the containment spray and emergency service water systems on high drywell pressure and low-low reactor water level to provide drywell sprays and suppression pool cooling for 48 hours. Success is one containment spray pump train, one associated containment spray heat exchanger, and one associated emergency service water pump train providing actuation, injection, and cooling of drywell sprays using torus water. Failure of event DS for 30 minutes or longer results in high suppression pool temperatures which would result in questionable core and containment spray pump performance as a result of the probable loss of net positive suction head (NPSH). This is assumed to result in containment failure as a result of drywell overpressure. Failure of event DS demands other measures such as operator action in aligning the fire protection water system to the core spray system (event FP) to provide core cooling without using core spray pumps even with the containment assumed to be failed. This event is monitored by SPDS through drywell and suppression pool pressure and temperature.

4.1.6 Long Term Core Spray Injection (Event LT)

Event LT is continued operation of core spray injection for 48 hours. Success is achieved by the operator taking the actions necessary to utilize redundant core spray system components to maintain injection. Success of event LT leads to stable decay heat removal using core spray, containment spray, and suppression pool cooling (success state S1). Failure of event LT demands other measures to provide core cooling without using core spray pumps such as operator action in aligning the fire protection system to the core spray system (event FP). This event is monitored by SPDS through RPV level, suppression pool temperature and level.

4.2 SPDS Detection

A break inside the containment that results in high drywell pressure and low RPV pressure will trigger the Primary System Integrity CSF to the alarm mode. If drywell pressure reaches drywell structural limits then the Containment Integrity CSF will change to the warning or alarm modes depending on setpoints used. The Containment Integrity CSF will also be triggered by suppression pool structural limits setpoints as monitored by pool level, temperature and air space pressure. It is to be emphasized here that the SPDS contains all vessel, drywell and suppression pool available level, temperature and pressure parameters, which would completely monitor their integrity and heat removal status. The fuel clad integrity and containment of radioactivity CSFs may also be activated if relevant parameters setpoints are reached. The overall SPDS response to L1 is shown on Table 4.2.

The final SPDS list shown in Table 3.1 was arrived at only after going through the OPSA and the other scenarios listed in Table 4.1. A number of parameters were deleted and added in this process before the final list was arrived at.

TABLE 4.1

TRANSIENTS / ACCIDENTS SCENARIOS

° Transient Accident Initiators

- T1 Reactor Trip
- T2 Partial Pressurization
- T3 Full Pressurization
- T4 Loss of Offsite Power
- T5 Loss of Feedwater Flow
- T6 Excessive Feedwater Flow

° Loss of Coolant Accident (LOCA) Initiators

- L1 Large/Intermediate Break, Below Core, Inside Containment
- L2 Small Break, Below Core, Inside Containment
- L3 Large/Intermediate Break, Above Core, Inside Containment
- L4 Small Break, Above Core, Inside Containment
- L5 Large/Intermediate Break, Below Core, Outside Containment
- L6 Small Break, Below Core, Outside Containment
- L7 Large/Intermediate Break, Above Core, Outside Containment
- L8 Small Break, Above Core, Outside Containment
- L9 Inadvertent Opening of One Relief Valve
- L10 Inadvertent Automatic Depressurization System (ADS) Actuation

° Others

- Reactivity Transients (Rod Withdrawal Errors and Rod Drop)
- Failure of the Off-gas System
- Oyster Creek May 2, 1979 Event

TABLE 4.2.

SPDS RESPONSE TO L1

	CSFs	MODE	REASON
1.	RCS Integrity/Primary System Integrity	Alarm	High Drywell Pressure & Low RPV Pressure
2.	Heat Removal/Primary System Cooling	Alarm	Level below Low-Low
3.	Heat Removal/Fuel Clad Cooling	Alarm	Level below Low-Low-Low (or on core spray operation)
4.	Containment Conditions/ Containment Cooling	Alarm	High Drywell Pressure (2 psig)/high torus temperature/limit curves violation
5.	Containment Conditions/ Containment Integrity	Alarm	If drywell pressure/torus air space pressure/torus level reach structural limits
6.	RCS Integrity/Fuel Clad Integrity	Alarm	If drywell radiation monitors/combustible gases monitors reach alarm setpoint
7.	Containment of Radioactivity	Alarm	If area radiation monitors in reactor building around isolation condensers, clean-up system piping, etc. reach alarm setpoint.

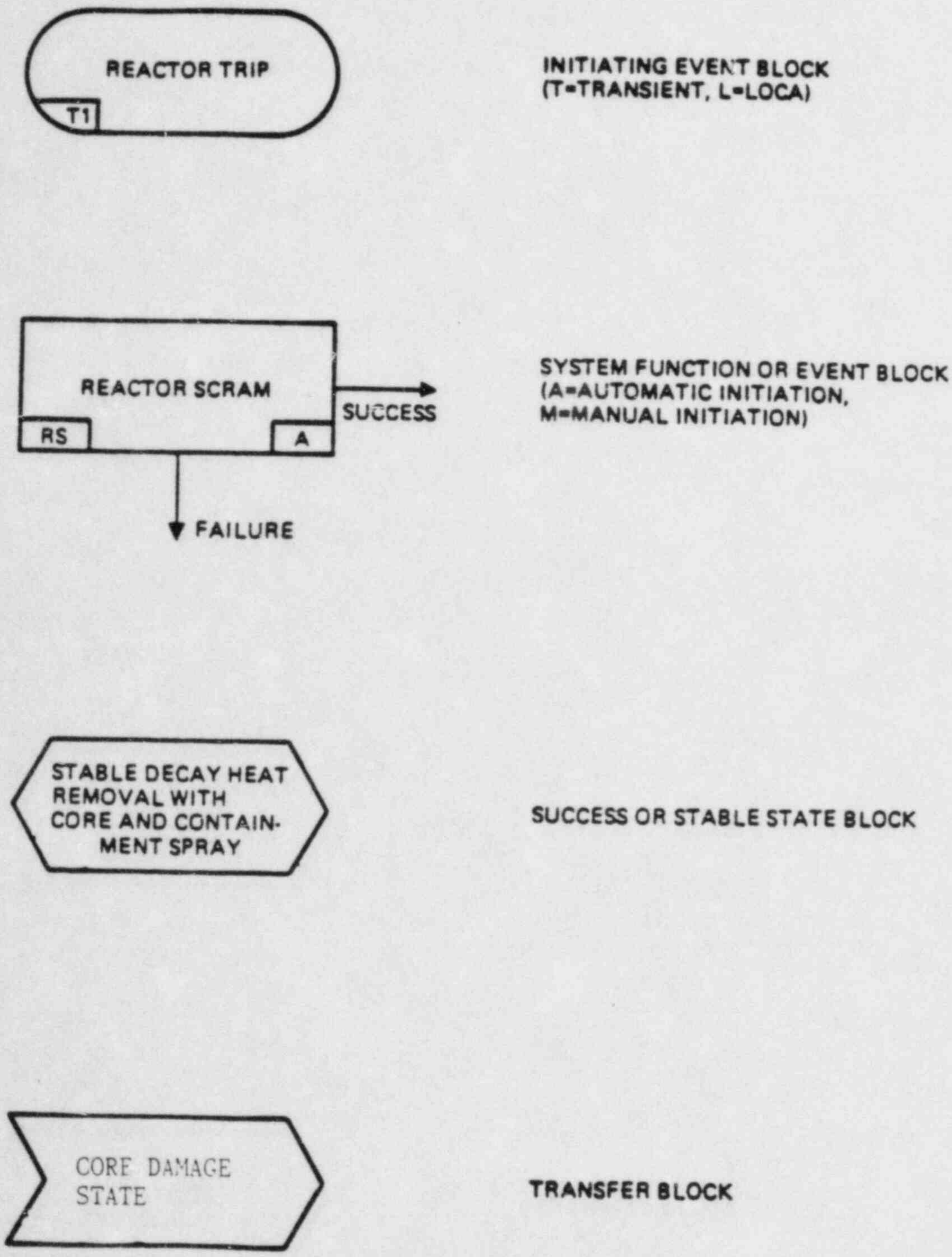

FIGURE 4-1: EVENT SEQUENCE DIAGRAM SYMBOLS

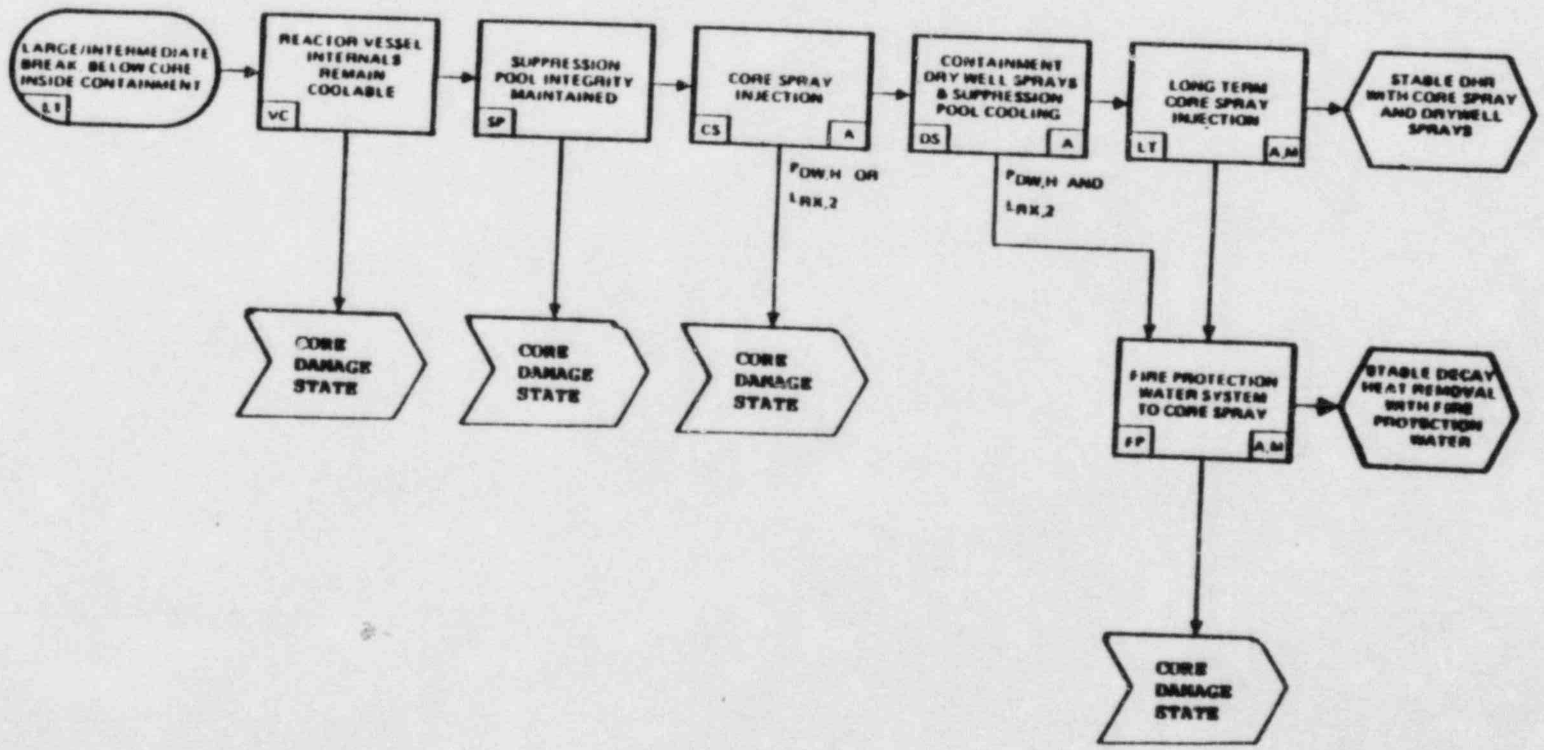

FIGURE 4-2: LOCA EVENT SEQUENCE DIAGRAM L1

5.0 REFERENCES

1. BWROG Committee on Display / Procedures Integration, Project Plant. September 14, 1983

2. NSAC/21, "Fundamental Safety Parameter Set for Boiling Water Reactors," prepared by S. Levy Inc. December 1980

3. Guidelines for an Effective Safety Parameter Display System Implementation Program. NUTAC, January 1983.

4. OPSA, Oyster Creek Probabilistic Safety Analysis, Plant Analysis Update PLG-0253 (unpublished). December 1982

5. Oyster Creek SPDS Parameter Selection and Safety Analysis Study. TDR 509 - Draft.