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Westinghouse Non-Proprietary Class 3

AP600 SYSTEM/EVENT MATRIX

Westinghouse Energy Systems

WCAP-13793,

AP600 SYSTEM/EVENT MATRIX

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WCAP-13793, REV. 0

AP600 SYSTEM/EVENT MATRIX

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AP600 RECORD OF CHANGES

Form 58204 (1-91)

AP600 DOCUMENT NO. GW-GSY-001 REVISION 1

ALTERNATE DOC. NO. WCAP-13793

DESIGN AGENT ORGANIZATION Westinghouse

TITLE AP600 SYSTEM/EVENT MATRIX

CHANGE NUMBER	PARAGRAPH NUMBER	CHANGE DESCRIPTION AND REASON	ENGINEER APPROVAL/DATE
1	All	Extensive revisions made to clarify and incorporate DCPs (94-116/0, GW-GEE-130/0)	
2	3.1.3.2	New sections added to provide discussion of each event.	
3	3.0	Added two shutdown events (loss RNS and RCS drain during mid-loop)	

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1.0 INTRODUCTION

This document describes how the AP600 systems are used to protect the reactor core during different events. The following sections contain evaluations for a wide range of events. The initial conditions include full power and several shutdown conditions. For each event, different safety and nonsafety-related systems that can protect the core are listed. Systems that provide reactor shutdown, RCS makeup, core decay heat removal, and containment cooling are identified. In addition, the type of actuation and electrical power requirements for each system are also shown.

The purpose of this document is to demonstrate that there are multiple levels of defense for each type of event. For more probable events there should generally be more levels of defense to provide the additional protection required. The systems that are nuclear safety-related are identified.

2.0 DESCRIPTION OF FUNCTIONS AND SYSTEMS

The functions addressed in this document are those necessary to protect the reactor core during an accident:

- Reactor Shutdown (Trip)
- Reactor Coolant System (RCS) Inventory Control
- Core Decay Heat Removal
- Containment Cooling

2.1 Reactor Shutdown

Reactor shutdown includes the equipment necessary to reduce the power generation to zero in a timely fashion and to provide and maintain an adequate shutdown margin. The control rods usually provide this shutdown function. They are automatically inserted by the Protection and Safety Monitoring System (PMS) in response to one of the signals listed in Table 2-1. The PMS opens breakers that de-energize magnets that hold the rods out of the core. The PMS, control rods, and trip breakers are safety-related.

The control rods can also be automatically inserted by a nonsafety-related Diverse Actuation System (DAS) in response to one of the signals listed in Table 2-5. The DAS is similar to the AMSAC provided in conventional Westinghouse PWR plants, except that DAS has several additional functions. DAS is designed to be diverse from the PMS to reduce the chance of common mode failures in the signal processing equipment. DAS inserts the control rods by de-energizing the control rod motor-generator (MG) set field so that the power to the trip breakers is interrupted. This causes the control rod drive magnets to de-energize and allows the rods to enter the core. Control rod insertion may be slower under DAS control than by PMS because of the limited number of sensors, setpoints, and the characteristics of the MG sets. However, it is fast enough to prevent the RCS from exceeding its upset pressure limit using best estimate analysis.

The rods can also be inserted by operator manual control action. There are dedicated safety-related switches mounted on the main control board that are hard-wired directly to the trip breakers. There are also dedicated nonsafety-related switches associated with the DAS that can insert the control rods by de-energizing the MG sets in the same manner described above for DAS.

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The control rods can also be automatically inserted by a nonsafety-related Diverse Actuation System (DAS) in response to one of the signals listed in Table 2-3. The DAS is similar to the AMSAC provided in conventional Westinghouse PWR plants, except that DAS has several additional functions. DAS is designed to be diverse from the PMS to reduce the chance of common mode failures in the signal processing equipment. DAS inserts the control rods by de-energizing the control rod motor-generator (MG) set field so that the power to the trip breakers is interrupted. This causes the control rod drive magnets to de-energize and allows the rods to enter the core. Control rod insertion may be slower under DAS control than by PMS because of the limited number of sensors, setpoints, and the characteristics of the MG sets. However, it is fast enough to prevent the RCS from exceeding its upset pressure limit using best estimate analysis.

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Another means of shutting down the reactor is to "ride out" the transient. The negative moderator temperature coefficient of the primary coolant causes the reactor to reduce the power as the coolant temperature increases and density decreases. Protective actions which occur while "riding out" a transient are; the turbine is tripped, the Pressurizer safety valves open, and the Passive Residual Heat Removal Heat Exchanger (PRHR HX) is aligned automatically by the DAS. In addition, the operator borates the RCS to bring it down from about 5% power to 0%. The Chemical and Volume Control System (CVS) or the Core Makeup Tanks (CMTs) can be used to provide this function.

In a large Loss of Coolant Accident (LOCA), it is assumed that the control rods do not enter the core because of possible deformations in the reactor internals. In this case, the reactor is initially shutdown by the formation of voids in the coolant. Later, boron added via the CMT and accumulator safety injection water reduces reactivity and provides the necessary shutdown margin.

2.2 RCS Inventory Control

RCS inventory can be maintained by a number of different systems. In many situations the normal RCS makeup is by the Chemical and Volume Control System (CVS). The CVS has two nonsafety-related high pressure pumps; one is started and stopped automatically by the Plant Control System (PLS) in response to the signals listed in Table 2-5. The pumps are automatically loaded onto the nonsafety-related diesel generators if offsite power is lost. For RCS leaks greater than 3/8", the CVS typically cannot provide sufficient RCS makeup and the Passive Core Cooling System (PXS) will be actuated.

The PXS provides the safety-related method of making up water to the RCS. For non-LOCA events, the CMTs will be actuated by the PMS by one of the signals listed in Table 2-2. The CMTs provide sufficient makeup to accommodate RCS leakage and cooldown shrink during non_LOCA events without ADS actuation. The CMTs use gravity to provide RCS injection. To make gravity effective a pressure balance line is connected from the CL to the top of the CMT. This line allows for two different modes of CMT operation. One mode is water recirculation which is used for non-LOCA events and the early stages of LOCAs. In this mode, hot water from the CL circulates to the CMT and cold CMT water is injected into the reactor by natural circulation. The other mode of operation is steam displacement which is used to provide greater injection rates during LOCAs.

For events where there is significant RCS leakage, additional PXS injection sources are utilized. These sources inject at lower pressures after the Automatic Depressurization System (ADS) is actuated.

The ADS is automatically actuated when the CMT level reaches a volume setpoint of 67%. This setpoint actuates the first stage of ADS. The second and third stages are actuated by timers in about 4 minutes following the first stage. Following ADS actuation, the operational procedure is to start the Normal Residual Heat Removal System (RNS). The RNS provides injection into the RCS from the IRWST at about 100 psig. This injection stops the CMT injection and prevents the fourth stage ADS valves from being actuated. This feature prevents containment pressurization and flooding. This also reduces risk to the public in case multiple failures occur in the ADS valves or the check valves from the In-Containment Refueling Water Storage Tank (IRWST). If there is a RNS equipment or operator failure, the fourth stage ADS valves open and allow gravity injection to the reactor from the IRWST. When the IRWST empties, water recirculates from the containment through the containment sump recirculation lines into the reactor vessel under gravitational force. The water is heated to steam in the reactor. It vents into the containment through the ADS. The passive containment cooling system condenses the steam making it available for injection into the reactor.

In case there are multiple failures in the PMS, the DAS provides automatic actuation of some of the PXS functions. To reduce the chance of inadvertent actuation, the ADS has to be manually actuated if the PMS fails. The PXS also can provide RCS makeup for small LOCAs if the CMTs fail. In this case, the operators manually actuate the ADS and the accumulators provide the necessary high pressure RCS makeup. These manual actuations are available through dedicated switches on the main control board.

During plant shutdown these systems are capable of providing RCS makeup. Automatic CMT actuation and subsequent ADS is provided on low pressurizer level during hot and cold shutdowns. During mid loop, the ADS is required to be open and the only safety-related action required is to open the IRWST MOV isolation valves. This opening is automatic via DAS based on low HL level and manual via PMS.

2.3 Reactor Core Decay Heat Removal

Core decay heat removal is provided by a number of different systems. In many situations the nonsafety-related Startup Feedwater System (SFW) is able to provide sufficient feedwater to the steam generator (SG) to permit core decay heat removal. The SFW has two high pressure pumps that are started automatically by the PLS in response to one of the signals listed in Table 2-5. These pumps are automatically loaded onto nonsafety-related diesels if offsite electrical power is lost. Initially, the SFW flow to each SG is controlled to a pre-determined flow rate. After the normal SG level is attained, the controller switches to SG level control. This control sequence minimizes the chance of overcooling the RCS and overfilling the SG.

If the SFW fails, the PRHR HX is automatically actuated by one of the PMS signals listed in Table 2-2. Manual PMS actuation is also provided. Automatic actuation by the DAS is provided (Table 2-4) as well as manual DAS actuation. The PRHR HX removes heat from the reactor by natural circulation. The heat is transferred to the IRWST. If the PRHR HX operation continues for more than 3 hours the IRWST starts to boil. In the longer term steam is vented to the containment where it is condensed. Most of the condensate drains down the containment wall and back into the IRWST.

If the PRHR HX fails, the SG inventory boils down in about an hour. As SG heat removal becomes ineffective, the RCS heats up. The RCS begins to boil off through the Pzr safety valves to the containment. The CMTs are automatically actuated by the PMS on a low SG level plus high RCS HL temperature signal. The CMTs provide RCS makeup. If this cooling mode continues long enough, the CMT level drops to the ADS setpoint (67%) and ADS is automatically initiated. As described in Section 2.2, after ADS is initiated, there are several variations in how the ADS/RNS/accumulators can work together to provide core cooling, depending on the types of failures.

During plant shutdown conditions, these same systems are capable of cooling the core. The following discusses the plant response to a loss of core cooling at hot shutdown. During hot and cold shutdown conditions, the RNS is initially operating. Automatic re-start of the RNS is the first level of defense. The CMTs and the PRHR HX are automatically actuated on low pressurizer level as the RCS inventory is discharged through the RNS relief valve. If the passive RHR heat exchangers fail, the RCS and CMT inventory are used to provide core cooling. When the CMT level drops sufficiently, it actuates ADS to reduce the pressure to allow IRWST gravity injection. Accumulator injection is not required because of the lower initial pressures and temperatures.

During mid-loop operation, the RNS functions as in hot or cold shutdown. Mid-loop conditions do not permit the PRHR HX to function since the RCS cannot be pressurized. Prior to entering into mid-loop condition, the ADS Stages 1, 2 & 3 valves are opened. In this case, the only action required is to align the IRWST to provide core cooling. This is accomplished by opening the MOV isolation valves manually or automatically via DAS.

2.4 Containment Cooling

Normal containment cooling is provided by non-safety related fan coolers. These redundant fans are powered by the non-safety diesel generators. The fan coolers are able to cool the containment as long as there is not a significant heat input of decay heat from the PRHR HX or from a RCS leak (>1"). If the heat input is too great, then the Passive Containment Cooling System (PCS) operation is required.

The PCS provides safety grade containment cooling. It is actuated by the PMS (Table 2-2) and by the DAS (Table 2-4). Manual actuation via PMS and DAS is also available. PCS actuation allows the gravity drain of water onto the outside of the steel containment vessel. Heat transfer through the containment wall evaporates water. Natural circulation air flow continually removes the water vapor. Two other sources of cooling water are also available. One source is the fire water system and the other is the demineralized water system. Fire water or demineralized water may be sprayed onto the outside of the containment. When fire water is used, natural circulation of air over the containment is not needed to keep the containment below its design pressure. As a final level of defense, natural convection air cooling alone has been determined to be sufficient to prevent containment failure. Although the containment design pressure is exceeded, sufficient pressure is not produced to cause failure.

Containment integrity and the PCS are required during at power modes and hot shutdown. They are not required during cold shutdown conditions when the RCS is not drained or during refueling conditions. In mid-loop conditions containment closure is required as well as PCS.

Table 2-1: Reactor Trip Signals

Description	Signal
Nuclear Startup	- Source range high neutron flux or - Intermediate range high neutron flux or - Power range high neutron flux (low setpoint)
Overpower	- Power range high neutron flux (high setpoint) or - Power range high positive flux
Core Cooling	- Over Temperature ΔT or - Overpower ΔT or - Low pressurizer pressure or - Low reactor coolant cold leg flow or - Low reactor coolant pump speed or - Reactor coolant pump bearing water high temp.
Reactor Overpressurization	- High pressurizer pressure or - High pressurizer water level
Loss of Heat Sink	- Low SG level (narrow range)
Feedwater Isolation	- High-2 SG level
ADS Actuation	- ADS actuation signal
Safety Injection	- Safety injection actuation (S) signal
Turbine Trip	- various signals, (e.g. high vibration, high lube oil temp., low lube oil flow)

Table 2-2: Engineered Safety Features Actuation Signals

Action	Signal
S Signal	- Low-1 pressurizer pressure or - Hi-1 Containment pressure or - Low compensated steam line pressure or - Low-3 Cold Leg Temp. or - Manual actuation
Containment Isolation	- S signal - Manual actuation - Manual actuation of containment cooling
PRHR HX Initiation	- Low SG level (Narrow Range) in any SG + low SFW flow after time delay or - Low SG level (Wide Range) in any SG or - CMT actuation or - ADS actuation or - Manual actuation
CMT Initiation	- S signal or - Low-2 pressurizer level or - High Hot Leg temperature + Low SG Level (Wide Range) or - Manual actuation
ADS - First Stage	- Low-1 CMT level in either CMT + CMT actuation signal or - Manual actuation
- Second Stage	- 1st stage ADS signal + time delay
- Third Stage	- 2nd stage ADS signal + time delay
- Fourth Stage	- Low-2 CMT level in either CMT + 3rd stage ADS signal + time delay or - Manual actuation
RCP Trip (Note 1)	- CMT actuation signal or - ADS stage 1 initiation or - High pump bearing temperature
Passive Containment Cooling	- Hi-2 Containment pressure - Manual actuation

Note (1) Reactor coolant pump trip is delayed 15 sec to allow reactor trip to occur first

Table 2-3: Safety-Related Isolation of non-Safety Systems

Action	Signals
Main Feedwater Isolation, Close MFW control & Isolation valves & Trip MFW pump	- Low-1 RCS Tc or - Hi-1 SG narrow range level or - S signal or - Manual actuation
Startup Feedwater Isol.	- Low-2 RCS Tc or - Hi-2 SG narrow range level
Steam Line Isolation	- Low steam line pressure or - Low-2 RCS Tc or - Hi-1 containment pressure or - Low-2 SG narrow range level - Manual actuation
SG Blowdown Isolation	- PRHR HX actuation signal
CVS Suction Aligned to BAT & demin. water isol.	- Reactor Trip or - CMT actuation or - Source range high neutron flux or - Loss of offsite power
CVS Flow Isolation	- Hi-2 SG level (narrow range) or - High pressurizer level
Pzr Heater Trip	- CMT actuation (1)

Note (1) Automatic trip is nonsafety-related. Manual local breaker trip is safety-related.

Table 2-4: Diverse Actuation Signals

Action	Signal
Reactor Trip (Note 1)	- Low SG wide range level or - Low pressurizer level or - Manual initiation
Turbine Trip	- Low SG wide range level or - Manual initiation
PRHR HX Actuation	- Low SG wide range level or - High Hot Leg temperature or - Manual initiation
CMT Actuation	- Low pressurizer level or - Manual initiation
Passive Containment Cooling	- High containment temperature - Manual initiation
Critical Containment Isolation Valves (Note 2)	- High containment temperature - Manual initiation
RCP Trip	- Low pressurizer level
Initiate IRWST Injection (Mid-loop operation)	- Low hot leg level
ADS Valves	- Manual initiation
Containment Hydrogen Ignitors	- Manual initiation
SG overfill protection	- Manual initiation

Notes:

(1) De-energization of control rod MG set field causes the control rods to enter the reactor core.

(2) Those containment penetration lines normally open and connected directly to the RCS or the containment.

Table 2-5: Nonsafety-Related System Actuation Signals

Action	Signal
Start/Stop CVS Makeup Pumps	
- 1 pump (Notes 1 & 2)	- Low pressurizer level (relative to programmed level)
Start SFW Pumps	- Low SG level (narrow range) in any SG or - Low feedwater flow to either SG
Auto SFW Flow Control	- SG level above low SG level (narrow range) setpoint
Containment Fan Cooler Control	- Containment temperature

Notes:

1. Flow controlled to a pre-set flowrate, less than 100 GPM. The pump is stopped on a high relative level.
2. On CMT actuation signal, one CVS pump injects at its maximum flow. Start/stop Pzr level setpoints are less than zero power setpoints.

3.0 DESCRIPTIONS OF EVENTS

Table 3-1 lists the events that are evaluated in this document. The list includes 11 full power events and 6 shutdown events. This list of events is not intended to be comprehensive. There are other postulated events which would require protective actions to prevent damage to the reactor core. The events which are evaluated in this document are expected to envelope these other events. Events that primarily challenge the reactor shutdown are considered to be similar to the Loss of Main Feedwater, Large Steam Line Break or the Loss of Coolant Accident events and are not separately described.

For each event, a summary description, an operational flow chart and a systems controls actions table are provided. The summary describes the safety-related and nonsafety-related systems which mitigate the consequences of the event. These systems are grouped into levels of defense that protect the reactor core. The flow charts depict the expected sequence of use of the different groups of systems. These flow charts show the levels of defense from an operational point of view. For example, following a loss of main feedwater, the startup feedwater pumps start automatically. If the SFW fails, the PRHR HX is aligned automatically. If that fails, the CMTs are aligned automatically, which leads to automatic ADS (passive feed and bleed). If that fails, the operators can manually start ADS. The flow charts are organized to show system actuations in the same order that would occur considering automatic controls and emergency operating procedures (EOPs).

Each group of systems is shown in a box which briefly lists the systems and indicates how they are actuated (manually or automatically). If a group of systems operates properly, the arrow to the right shows the resulting plant state, e.g, "Success, no ADS". If they fail, then the arrow from the bottom of the box leads to the next level of defense.

Each event has a table listing the supporting instrumentation and electrical systems which support the operation of the mitigating systems. Each table shows the systems available that can provide reactor shutdown, RCS inventory control, core cooling, and containment cooling. For each system information is shown indicating the source of the supporting I&C actuation and electrical power. Three different I&C systems are shown, the Plant Control System (PLS), the Protection and Safety Monitoring System (PMS), and the Diverse Actuation System (DAS). The PLS and the DAS are nonsafety-related systems and the PMS is a safety-related system. Automatic or manual actuation is identified under the I&C system as an "A" or "M". Note that automatic actuations may be performed manually through the same I&C system. For the PMS there are safety related main control board manual control through both component level soft controls and through dedicated system level switches. For the DAS there are nonsafety-related dedicated system level switches. For the PLS there are nonsafety-related soft control switches. This evaluation does not identify the instruments used to actuate the various systems.

If DC or AC power is also required for operation of equipment in that system, this is indicated by a "Yes". In many of the PMS actuations, no DC power is required for passive system operation; i.e. all that is required is to remove power and allow "fail safe" equipment to go to their preferred failure position.

Table 3-1: List of Events

	Event	Initial Condition
3.1.1	Loss of Main Feedwater	Full Power
3.1.2	Loss of Offsite Power	Full Power
3.1.3	Loss of All AC Power	Full Power
3.1.4	Small Steam Line Break	Full Power
3.1.5	Large Steam Line Break	Full Power
3.1.6	Steam Generator Tube Rupture	Full Power
3.1.7	RCS Leak (0 to 3/8")	Full Power
3.1.8	RCS Leak (3/8" to 1")	Full Power
3.1.9	Small LOCA (1" to 10")	Full Power
3.1.10	Large LOCA (>10")	Full Power
3.1.11	Earthquake (SSE)	Full Power
3.2.1	Loss of Offsite Power	Hot Standby
3.2.2	Loss of Offsite Power	Hot/Cold Shutdown
3.2.3	Loss of Offsite Power	Mid Loop
3.2.4	Inadvertent RCS Drain	Mid Loop
3.2.5	Loss RNS	Mid Loop
3.2.6	Loss of Offsite Power	Refueling

3.1 At Power Events

3.1.1 Loss Of Main Feedwater From Full Power

First Line of Defense

The loss of feedwater to the steam generator while the reactor is at full power is a significant primary system heat-up transient event. The loss of feedwater can be due to a pipe break in the turbine building or the failure or loss main feedwater pump function. At the time of loss of feedwater, low feedwater flow alarm causes the startup feedwater (SFW) pumps to start. Despite SFW pump operation, the steam generator secondary side water boils down. The level decreases and the narrow range low level setpoint causes the reactor to trip. The reactor coolant pumps continue to operate. When the steam generator level is re-established, the feedwater flow is automatically controlled to maintain the level. The CVS provides RCS makeup as necessary for losses due to leaks and cooldown contraction.

Second Line of Defense (Safety Case)

If the startup feedwater system does not provide feedwater, the steam generator wide range low level setpoint is reached and the PRHR HX is aligned. This allows primary coolant from the hot leg to pass through the heat exchangers where heat is transferred to the IRWST. The passive containment cooling system (PCS) provides containment cooling after the IRWST begins steaming. The CMTs provide RCS makeup as necessary to accommodate leakage and cooldown contraction.

Third Line of Defense

If the PRHR HXs are not aligned, the steam generators boil dry in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature will rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer causes a loss of inventory from the primary coolant system. The low wide range steam generator level with coincident high reactor coolant system hot leg temperature aligns the CMTs and trips the reactor coolant pumps.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operational procedure is to align the RNS to inject IRWST water into the RCS. This injection stabilizes the CMT level and prevents actuation of ADS Stage 4.

The normal residual heat removal system (RNS) also provides long term decay heat removal which makes operation of the PCS unnecessary.

Fourth Line of Defense

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term cooling of the containment.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term cooling of the containment.

3.1.2 Loss Of Offsite Power From Full Power

First Line of Defense

The loss of offsite electrical power while the reactor is at full power is normally accommodated by a transfer to the turbine generator without a reactor trip. If this transfer is unsuccessful, the reactor trips and the diesel generators are started. After start of the diesel generators, the SFW pumps are automatically loaded and started. The feedwater supplied by the SFW system allows the Sgs to remove decay heat. The CVS provides RCS makeup as necessary for losses due to leaks and cooldown contraction.

Second Line of Defense (Safety Case)

In the event that the SFW pumps and CVS are not available, the steam generator will boil down. The SG wide range low level setpoint will be reached and the PRHR HX actuated. This allows primary coolant from the hot leg to pass through the heat exchangers where heat is transferred to the IRWST. The passive containment cooling system (PCS) provides containment cooling after the IRWST begins steaming. The CMTs provide RCS makeup as necessary to accommodate leakage and cooldown contraction.

Third Line of Defense

If the PRHR Hxs are not aligned, the steam generators boil dry in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature will rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer to the IRWST causes a loss of inventory from the primary coolant system. The low wide range steam generator level with coincident high reactor coolant system hot leg temperature aligns the CMTs.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operational procedure is to align the RNS to inject IRWST water into the RCS. This injection stabilizes the CMT level and prevents actuation of ADS Stage 4.

The normal residual heat removal system (RNS) also provides long term decay heat removal which makes operation of the PCS unnecessary.

Fourth Line of Defense

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.3 Loss Of All AC Power From Full Power

First Line of Defense (Safety Case)

The loss of all AC electrical power while the reactor is at full power assumes unsuccessful transfer to the turbine generator and failure of the diesel generators. The reactor coolant pumps and feedwater pumps coast down. A low RCP speed signal trips the reactor, although in any case the rods will insert due to the loss of all AC power.

Because there is no AC power, the SFW pumps and CVS are not available. Because the startup feedwater system does not provide feedwater, the steam generator wide range low level setpoint is reached and the PRHR HX is actuated. This allows primary coolant from the hot leg to pass through the heat exchangers where heat is transferred to the IRWST. The passive containment cooling system (PCS) provides containment cooling after the IRWST begins steaming. The CMTs provide RCS makeup as necessary to accommodate leakage and cooldown contraction.

Second Line of Defense

If the PRHR HXs are not aligned, the steam generators boil dry in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature will rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer to the IRWST causes a loss of inventory from the primary coolant system. The low wide range steam generator level with coincident high reactor coolant system hot leg temperature aligns the CMTs.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. With the RNS unavailable to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling.

Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Third Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.4 Small Steam Line Break From Full Power

A small steam line break results in a larger RCS cool down transient when the reactor is at hot zero power conditions. The small steam line break while at full power produces a slower cool down transient, but is more challenging to reactor core cooling due to the larger amount of decay heat. A small steam line break event which occurs at the end of fuel life can result in temporary return to power due to the RCS olant's large negative temperature coefficient of reactivity. This event is assumed to result in a reactor trip but to not initially actuate safety related systems.

First Line of Defense

For this case the safety-related systems are not actuated and the reactor is tripped or manually shutdown. The reactor coolant pumps and feedwater pumps continue to operate. The operators isolate the SG with the broken steam line from the feedwater supply. These actions limit the cooldown and avoid actuation fo the safety-related systems. The SFW pumps start if the MFW pumps are lost or are unable to properly control SG level. CVS makeup provides RCS boration to recover shutdown margins and to accommodate RCS leakage and cooldown contraction.

Second Line of Defense (Safety Case)

If the operator does not take effective actions to limit the RCS cooldown, a low RCS temperature signal trips the reactor and the reactor coolant pumps, isolates main and startup feedwater, aligns the CMTs and the PRHR HX. The RCS coolant shrinks as it cools which adds positive reactivity to the core. The reactor may regain critically for a short time until the CMTs inject enough boron to shut the reactor down. The CMT operate in a water recirculation mode and do not drain down; ADS actuation is not approached. Cooling of the RCS occurs as the PRHR HXs transfer heat to the IRWST. After the IRWST begins steaming, the PCS provides the long term heat sink.

Third Line of Defense

If the PRHR HXs are not actuated, the steam generators boil dry in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature will rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer to the IRWST causes a loss of inventory from the primary coolant system. The CMTs are automatically actuated on a low SG level co-incident with a high RCS temperature.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached.

This actuates ADS Stage 1. As the CMTs drain into the primary system, automatic depressurization of the system begins when either CMT level drops to the ADS actuation setpoint. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operational procedure is to align the RNS to inject IRWST water into the RCS. This injection stabilizes the CMT level and prevents actuation of ADS Stage 4.

The normal residual heat removal system (RNS) also provides long term decay heat removal which makes operation of the PCS unnecessary.

Fourth Line of Defense

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.5 Large Steam Line Break From Full Power

A large steam line break results in a larger RCS cool down transient when the reactor is at zero power, hot conditions. A large steam line break while at full power produces a slower cool down transient, but is more challenging to reactor core cooling due to the larger amount of decay heat. A large steam line break event which occurs at the end of fuel life can result in temporary return to power due to the RCS coolant's large negative temperature coefficient of reactivity. This event results in a reactor trip and actuation of safety-related systems.

First Line of Defense (Safety Case)
The low steam line pressure causes a safeguards actuation (S) signal. This signal trips the reactor, trips the reactor coolant pumps and feedwater pumps, aligns the CMTs and the PRHR HX. The RCS coolant shrinks as it cools which adds positive reactivity to the core. The reactor regains critically for a time until the CMTs inject enough boron to shut the reactor down. The CMTs operate in the water recirculation mode and do not drain down; ADS actuation is not approached.

A low RCS temperature isolates the main and the startup feedwater lines which limits the cooldown. The PRHR HXs are automatically actuated to remove decay heat from the reactor and transfer that heat to the IRWST. The PCS provides long term cooling after the IRWST begins steaming. The CMTs also provide RCS makeup as necessary to accommodate leakage and cooldown contraction.

Second Line of Defense
If the PRHR HX is not actuated, the steam generators boil down in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer causes a loss of inventory from the primary coolant system. The CMTs are automatically actuated on a low SG level co-incident with a high RCS temperature.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate shortly afterwards on timers. When the RCS pressure has fallen to 100 psi, the operational procedure is to align the RNS to inject IRWST water into the RCS. This injection stabilizes the CMT level and prevents actuation of ADS Stage 4.

The normal residual heat removal system (RNS) also provides long term decay heat removal which makes operation of the PCS unnecessary.

Third Line of Defense

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fourth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.6 Steam Generator Tube Rupture From Full Power

First Line of Defense

The steam generator tube rupture while the reactor is at full power does not produce a severe thermal hydraulic transient. The significant effects are loss of RCS inventory outside of the containment and the potential release of radioactivity through the secondary side of the steam generator to the atmosphere. As the primary coolant flows into the steam generator, the RCS pressure falls and the pressurizer level decreases. Reactor trip and safeguards actuation (S) signals are generated in response to low pressurizer pressure. The S signal trips the reactor coolant pumps, isolates MFW and aligns the CMTs and the PRHR HX. The SFW pumps are actuated in response to low feedwater flow. One CVS makeup pump is started/stopped to maintain pressurizer level between 10% and 20%. The operator takes action to cool the RCS using the intact SG and reduces pressure using the CVS auxiliary spray into the pressurizer. As the RCS depressurizes to the SG pressure, flow of RCS coolant into the secondary side ceases.

Second Line of Defense (Safety Case)

If the startup feedwater system or the CVS makeup system malfunctions and provides excessive flow, the steam generator wide range high level setpoint is reached and the SFW pumps and CVS makeup pumps are isolated with safety related valves. After isolation of the SFW pumps and CVS makeup pumps, the CMTs provide RCS makeup and the PRHR HXs remove the core decay heat. When decay heat decreases to the level where the PRHR HX heat removal matches it, the RCS pressure drops to the SG pressure which terminates the tube leak. The CMTs do not drain to the level which actuates ADS. The PCS is available for containment cooling after the IRWST begins steaming.

This level of defense also applies to a case where the non-safety SFW and CVS systems fail to actuate; the CMTs and PRHR HXs function in the same manor to provide RCS makeup and remove decay heat, respectively.

Third Line of Defense

If the PRHR HXs are not aligned, the steam generators boil dry in about an hour. After the steam generator secondary side no longer removes heat, the primary system pressure and temperature will rise until the pressurizer safety relief valves open. The venting of steam from the pressurizer to the IRWST and the continued SG tube leak causes a loss of inventory from the primary coolant system. The CMTs are automatically actuated on a low SG level co-incident with a high RCS temperature.

Initially the core make-up tanks provide RCS injection drain water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operational procedure is to align the RNS to inject IRWST water into the RCS. This will stabilize the CMT level and prevent actuation of ADS Stage 4.

The RNS also provides long term decay heat removal which makes operation of the PCS unnecessary.

Fourth Line of Defense

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.7 RCS Leak (0 to 3/8") From Full Power

First Line of Defense

The CVS system has the capability of injecting water into the RCS at a rate which matches the loss RC water through a 3/8" hole. The CVS can maintain RCS pressure and permit the operator to perform a controlled shutdown. The SFW pumps provide feedwater to the SG to initially remove sensible and decay heat. The RNS will be used later to continue the cooldown.

Second Line of Defense

If the CVS fails to provide makeup to the RCS, the pressurizer low pressure signal will trip the reactor and generate a safety injection signal (S). This signal also trips the RCPs and actuates the CMTs and the PRHR HX. If the operators execute a manual reactor cooldown the CMTs will not drain down to the ADS actuation level. The RNS provides long term RCS cooling.

Third Line of Defense

If the CVS is unavailable and the manual reactor cooldown is not executed, the pressurizer low-low level alarm will generate a safeguards actuation (S) signal. This signal trips the reactor coolant pumps, aligns the CMTs and the PRHR HX. The CMTs and PRHR HXs provide RCS makeup and remove decay heat, respectively. The PRHR HXs transfer heat from the primary coolant to the IRWST. The PCS provides long term cooling of the reactor after the IRWST begins steaming.

Initially the core make-up tanks provide RCS injection while they operate in a water recirculation mode. Later in the event the RCS as the inventory depletes, the CLs void and the CMTs drain down. The drain down will continue until the CMT level drops to the ADS actuation level. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operators standard procedure is to align the RNS to inject IRWST water into the RCS. This will stabilize the CMT level and prevent actuation of ADS Stage 4.

The normal residual heat removal system (RNS) also provides long term decay heat removal which makes operation of the PCS unnecessary.

Fourth Line of Defense (Safety Case)

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.8 RCS Leak (3/8" to 1") From Full Power

First Line of Defense

Because the CVS has the capability of injecting water into the RCS at a rate which matches the RC water loss through a hole of 3/8", the CVS cannot match the RC water loss for a 1" leak. The pressurizer low pressure signal will trip the reactor and generate a safety injection signal (S). This signal also trips the RCPs and actuates the CMTs and the PRHR HX. If the operators execute a manual reactor cooldown the CMTs will not drain down to the ADS actuation level. The RNS will provide long term RCS cooling. The RNS will perform its decay heat removal function.

Second Line of Defense

If the CVS fails or the operator fails to execute a manual cooldown, the CMTs will drain down to the ADS actuation level. This will actuate the ADS Stage 1 valves. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operators standard procedure is to align the RNS to inject IRWST water into the RCS. This will stabilize the CMT level and prevent actuation of ADS Stage 4.

The RNS also provides long term decay heat removal which makes operation of the PCS unnecessary.

Third Line of Defense (Safety Case)

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT volume drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fourth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.9 Small LOCA (1" to 10") From Full Power

First Line of Defense

RCS low pressure generates a safeguards actuation (S) signal. This signal trips the reactor, trips the reactor coolant pumps, aligns the CMTs and the PRHR HX. The CMTs and PRHR HXs provide RCS makeup and remove decay heat, respectively. The PRHR HXs transfer heat from the primary coolant to the IRWST.

As the CMTs drain into the primary system, automatic depressurization of the system begins when either CMT volume falls to the ADS actuation setpoint. ADS Stages 2 and 3 actuate on timers within minutes. When the RCS pressure has fallen to 100 psi, the operators standard procedure is to align the RNS to inject IRWST water into the RCS. This will stabilize the CMT level and prevent actuation of ADS Stage 4.

The RNS also provides long term decay heat removal which makes operation of the PCS unnecessary.

Second Line of Defense (Safety Case)

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT volume drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST into the reactor to provide core cooling. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Third Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.1.10 Large LOCA (> 10") From Full Power

First Line of Defense

RCS low pressure or containment high pressure will generate a safeguards actuation (S) signal. This signal trips the reactor, trips the reactor coolant pumps, aligns the CMTs and the PRHR HX. The RCS pressure drops rapidly and the resulting blowdown essentially empties the RCS. The rapid drop in RCS pressure allows the accumulators to inject. The accumulator injection refills the reactor vessel down comer and refloods the core.

The CMTs function to continue safety injection until the RCS pressure drops to the point where IRWST injection begins. ADS operation is not necessary for this pressure reduction because of the large size of the break. The operators standard procedure is to align the RNS to inject IRWST water into the RCS. This will stabilize the CMT level and prevent actuation of 4th stage ADS.

The PCS provides short term cooling of the containment. The RNS provides long term cooling after the PCS has reduced the peak containment pressure.

Second Line of Defense (Safety Case)

If the RNS fails or is not aligned to inject IRWST water, the CMT level continues to drop. When either CMT volume drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into the containment. Steam released to the containment condenses on the inside of the containment vessel as the passive containment cooling system removes the heat. The condensed steam runs back down the inside wall and is collected in a gutter system and returned to the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

3.1.11 Earthquake (SSE) From Full Power

It is assumed that none of the non-safety related systems or equipment are available during or after a safe shutdown earthquake (SSE). The main feedwater system, the startup feedwater system and CVS makeup can not provide their injection functions.

First Line of Defense (Safety Case)
Because the startup feedwater system does not provide feedwater, the steam generator level will drop to a low level setpoint which trips the reactor, trips the reactor coolant pumps, aligns the CMTs and the PRHR HX. The CMTs and PRHR HXs provide RCS makeup and remove decay heat, respectively. This allows primary coolant from the hot leg to pass through the heat exchangers where heat is transferred to the IRWST. The PCS provides containment cooling after the IRWST begins steaming. The CMTs provide RCS makeup as necessary to accommodate leakage and cooldown contraction.

Second Line of Defense
If the PRHR HX is not aligned to remove heat from the RCS, the RCS pressure and temperature will rise until the pressurizer safety relief valves open. The RCS will lose inventory as the pressurizer steam vents into the IRWST. The CMTs are automatically actuated on a low SG level co-incident with a high RCS temperature.

Initially the core make-up tanks provide RCS injection by water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. Because the RNS is not available the CMT level will continue to drop. When the level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Third Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. The accumulators automatically inject cold, borated water into the reactor when the pressure drops to 700 psi. This injection provides adequate makeup until depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.2 Shutdown Events

3.2.1 Loss Of Offsite Power From Hot Shutdown

With the reactor at hot shutdown, the reactor is shutdown (rods inserted), the RCPs are operating and RCS cooling is provided by the RNS.

First Line of Defense
The loss of offsite electrical power while the reactor is at cold shutdown results in the coast down of the reactor coolant pumps. After the diesels start, the RNS pumps are automatically loaded to provide heat removal. The CVS pumps are also automatically loaded to provide RCS makeup as required.

Second Line of Defense
If the RNS pumps are not available, then the operators can isolate the RNS and use the SFW pumps to remove decay heat from the SG.

Third Line of Defense (Safety Case)
In the event that the diesel generators do not start, the RNS is not available. As a result the RCS temperature will increase. This will result in the RCS pressure increasing and the lifting of the RNS relief valve. The loss of RCS coolant through the RNS relief valve causes the Pzr level to decrease which automatically actuates the CMTs and the PRHR HX.

The PRHR HX are able to remove decay heat and transfer it to the IRWST. The PCS provides long term cooling after the IRWST begins steaming. The CMTs provide RCS makeup to compensate for the loss through the RNS relief valve and RCS leakage as required.

Fourth Line of Defense
If the PRHR HXs are not actuated, the RNS relief valve will continue to discharge water from the RCS. Initially the core make-up tanks provide RCS injection by water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. With the RNS unavailable to inject IRWST water, the CMT levels will continue to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through

the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. Because the RCS is at lower temperatures and pressures and decay heat is reduced the accumulators are not necessary. The ADS depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.2.2 Loss Of Offsite Power From Cold Shutdown

With the reactor at cold shutdown, the reactor is shutdown (rods inserted), the RCPs are operating and RCS cooling is provided by the RNS. In this case the RCS is assumed to be intact; reduced inventory conditions are addressed in cases 3.2.3 to 3.2.5. The containment is not required to be closed, however in most situations it is expected to be closed or capable of quick closing.

First Line of Defense

The loss of offsite electrical power while the reactor is at cold shutdown results in the coast down of the reactor coolant pumps. After the diesels start, the RNS pumps are automatically loaded to provide heat removal. The CVS pumps are also automatically loaded to provide RCS makeup as required.

Second Line of Defense

If the RNS pumps are not available, then the operators can isolate the RNS and use the SFW pumps to remove decay heat from the SG.

Third Line of Defense (Safety Case)

In the event that the diesel generators do not start, the RNS is not available. As a result the RCS temperature will increase. This will result in the RCS pressure increasing and the lifting of the RNS relief valve. The loss of RCS coolant through the RNS relief valve causes the Pzr level to decrease which automatically actuates the CMTs and the PRHR HX.

The PRHR HX are able to remove decay heat and transfer it to the IRWST. The PCS provides long term cooling after the IRWST begins steaming. The CMTs provide RCS makeup to compensate for the loss through the RNS relief valve and RCS leakage as required.

Fourth Line of Defense

If the PRHR HXs are not actuated, the RNS relief valve will continue to discharge water from the RCS. Initially the core make-up tanks provide RCS injection by water recirculation. Later on as the RCS inventory depletes the CMTs will drain down and eventually the ADS actuation level will be reached. This actuates ADS Stage 1. ADS Stages 2 and 3 actuate on timers within minutes. With the RNS unavailable to inject IRWST water, the CMT levels will continue to drop. When either CMT level drops to a low level, the 4th stage of ADS actuates and primary coolant is vented directly into containment. This final depressurization permits gravity drain of the IRWST. In the long term, the IRWST drains down and the water level in the containment rises until the water recirculates through the sump screen into the IRWST injection line. This mode of reactor cooling can continue indefinitely. The PCS provides long term containment cooling.

Fifth Line of Defense

If the CMTs fail to inject into the reactor vessel, the plant operators can manually actuate the ADS. Because the RCS is at lower temperatures and pressures and decay heat is reduced the accumulators are not necessary. The ADS depressurization permits gravity injection of the IRWST. The PCS provides long term containment cooling.

3.2.3 Loss Of Offsite Power From Mid-Loop

With the reactor at cold shutdown mid-loop conditions, the reactor is shutdown (rods inserted), the RCPs are stopped and RCS cooling is provided by the RNS. In this case the RCS is assumed to be in a reduced inventory condition with the water level in the HL. In mid-loop operation, the PRHR HXs are not available because the RCS is open to the containment. The containment is closed except for the personnel air locks which may be both open, but must be capable of being closed quickly. The technical specifications require the ADS Stage 1/2/3 to be open when in mid-loop conditions.

First Line of Defense

The loss of offsite electrical power while the reactor is at mid-loop condition causes a loss of AC power until the diesel generators start. After the diesels start, the RNS pumps are automatically loaded to provide heat removal. The CVS pumps are also automatically loaded to provide RCS makeup as required.

Second Line of Defense (Safety Case)

In the event that the diesel generators do not come on line, the RNS is not available. As a result the RCS temperature will increase and the RCS water starts to boil. When the HL level drops to a low level the IRWST MOV isolation valves opened manually through the PMS. In conjunction with the open ADS valves, this provides for effective RCS makeup and venting. The steam generated in the RCS will leave via the ADS valves into the IRWST where it is initially condensed. If there are other openings in the RCS some of this steam may bypass the IRWST and enter the containment. In the longer term the IRWST may drain down and recirculation from the containment sump will provide continued core cooling.

The PCS with containment closure provides the long term heat sink.

Third Line of Defense

This case is identical to the second case except that the IRWST MOV isolation valves are automatically opened via the DAS after a 30 minute delay.

3.2.4 Inadvertent RCS Drain From Mid Loop

First Line of Defense

The CVS makeup pumps are available to makeup for an inadvertent drain from the RCS. The operators will have to manually actuate the CVS based on HL level. The RNS should continue to operate and remove decay heat.

Second Line of Defense

In the event that the CVS makeup pumps are not available, the RNS pumps can be re-aligned to inject water from the IRWST to the RCS. The RNS HX would still be able to remove decay heat.

Third Line of Defense (Safety Case)

In case the CVS and the RNS are not available, RCS temperature will increase and the RCS water will boil. When the HL level drops to a low level the IRWST MOV isolation valves are manually opened through the PMS. In conjunction with the open ADS valves, this provides for effective RCS makeup and venting. The steam generated in the RCS will leave via the ADS valves into the IRWST where it is initially condensed. If there are other openings in the RCS some of this steam may bypass the IRWST and enter the containment. In the longer term the IRWST may drain down and recirculation from the containment sump will provide continued core cooling.

The PCS with containment closure provides the long term heat sink.

Fourth Line of Defense

This case is identical to the third case except that the IRWST MOV isolation valves are automatically opened via the DAS after a 30 minute delay.

3.2.5 Loss RNS From Mid Loop

First Line of Defense (Safety Case)

If both RNS pumps are lost, the RCS temperature will increase and the RCS water will start to boil. When the HL level drops to a low level the IRWST MOV isolation valves are manually opened through the PMS. In conjunction with the open ADS valves, this provides for effective RCS makeup and venting. The steam generated in the RCS will leave via the ADS valves into the IRWST where it is initially condensed. If there are other openings in the RCS some of this steam may bypass the IRWST and enter the containment. In the longer term the IRWST may drain down and recirculation from the containment sump will provide continued core cooling.

The PCS with containment closure provides the long term heat sink.

Second Line of Defense

This case is identical to the first case except that the IRWST MOV isolation valves are automatically opened via the DAS after a 30 minute delay.

3.2.6 Loss Of Offsite Power From Refueling

In refueling operation, the PRHR HXs are not available because the reactor vessel is opened to containment. The containment is not required to be closed, however it is expected that it can be quickly closed.

First Line of Defense

The loss of offsite electrical power while the reactor is at refueling conditions causes a loss of AC power until the diesel generators start. After the diesels start, the RNS pumps are automatically loaded to provide heat removal. The CVS pumps are also automatically loaded to provide RCS makeup as required.

Second Line of Defense

In case the RNS is not available the Spent Fuel Cooling System can also be used to remove decay heat. One of the SFS pumps will be aligned to the refueling cavity to provide purification.

Third Line of Defense (Safety Case)

In case neither the RNS or the SFS pumps are available, water in the refueling cavity can provide extended decay heat removal. It would take at least 6 hours to heatup to boiling and 72 hours to boil down to the top of the fuel. This capability provides time for the operators to recover RNS or SFP cooling, or to close the containment, or to secure onsite or offsite water makeup supplies.

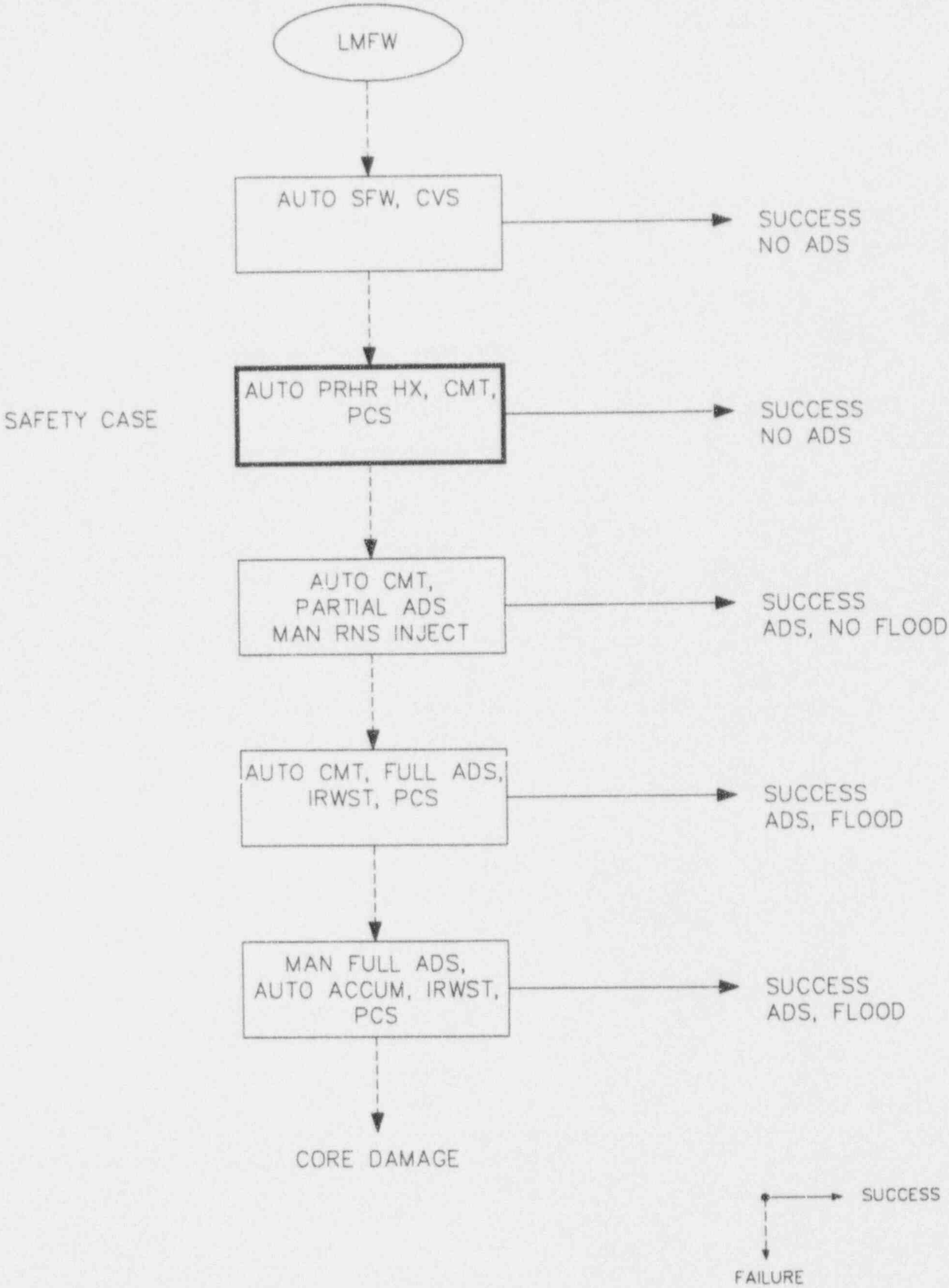


FIGURE 3.1-1: LOSS MAIN FEEDWATER AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
3. Ride Out (2)	M	Yes	Yes	-	-	A
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT	-	-	-	A	-	-
3. CMT	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW	A	Yes	Yes	-	-	-
2. PRHR HX	-	-	-	A	-	-
3. PRHR HX	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual CMT or CVS boration.

TABLE 3.1-1: LOSS MAIN FEEDWATER AT FULL POWER ACTUATION

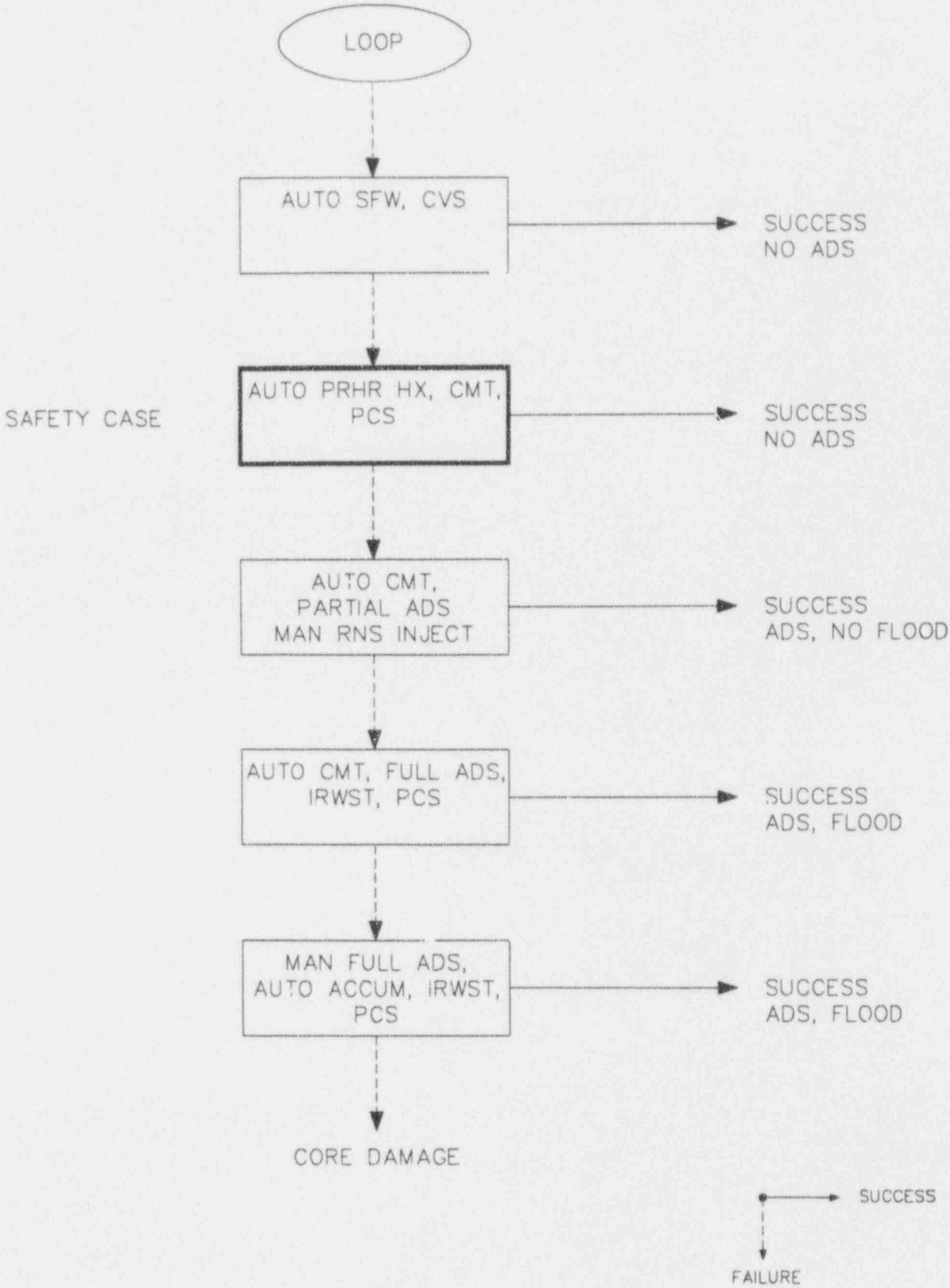


FIGURE 3.1-2: LOSS OFFSITE POWER AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
3. Ride Out (2)	M	Yes	Yes	-	-	A
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT	-	-	-	A	-	-
3. CMT	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW	A	Yes	Yes	-	-	-
2. PRHR HX	-	-	-	A	-	-
3. PRHR HX	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

2) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual CMT or CVS boration.

TABLE 3.1-2: LOSS OFFSITE POWER AT FULL POWER ACTUATION

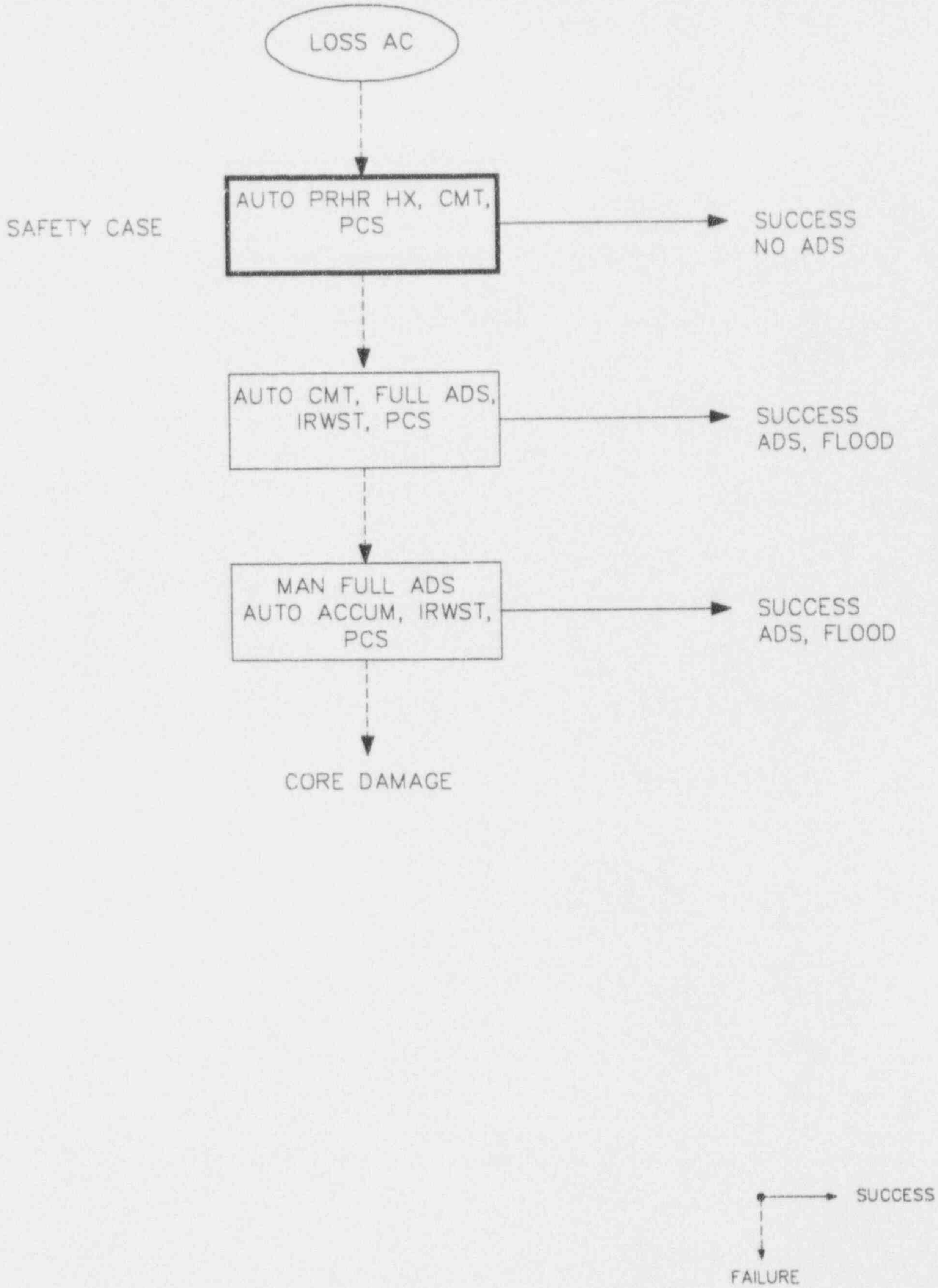


FIGURE 3.1-3: LOSS ALL AC POWER AT FULL POWER FLOW CHART

Function / System Order of Use	Actuation / Electrical Systems: Non-Safety PLS	Non-Safety DC	Non-Safety AC	Safety PMS	Safety DC	Diverse DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods (2)	-	-	-	-	-	-
2. Ride Out (3)	-	-	-	-	-	M
o RCS Inventory Control						
1. CMT	-	-	-	A	-	-
2. CMT	-	-	-	-	-	A
3. CMT, IRWST, full ADS	-	-	-	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	-	Yes	M
5. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. PRHR HX	-	-	-	A	-	-
2. PRHR HX	-	-	-	-	-	A
3. CMT, IRWST, full ADS	-	-	-	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	-	Yes	M
5. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air, water drain	-	-	-	-	-	A
3. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rod drive mechanisms are de-energized by loss of all AC power.
3) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual boration by CMTs.

TABLE 3.1-3: LOSS ALL AC POWER FEEDWATER AT FULL POWER ACTUATION

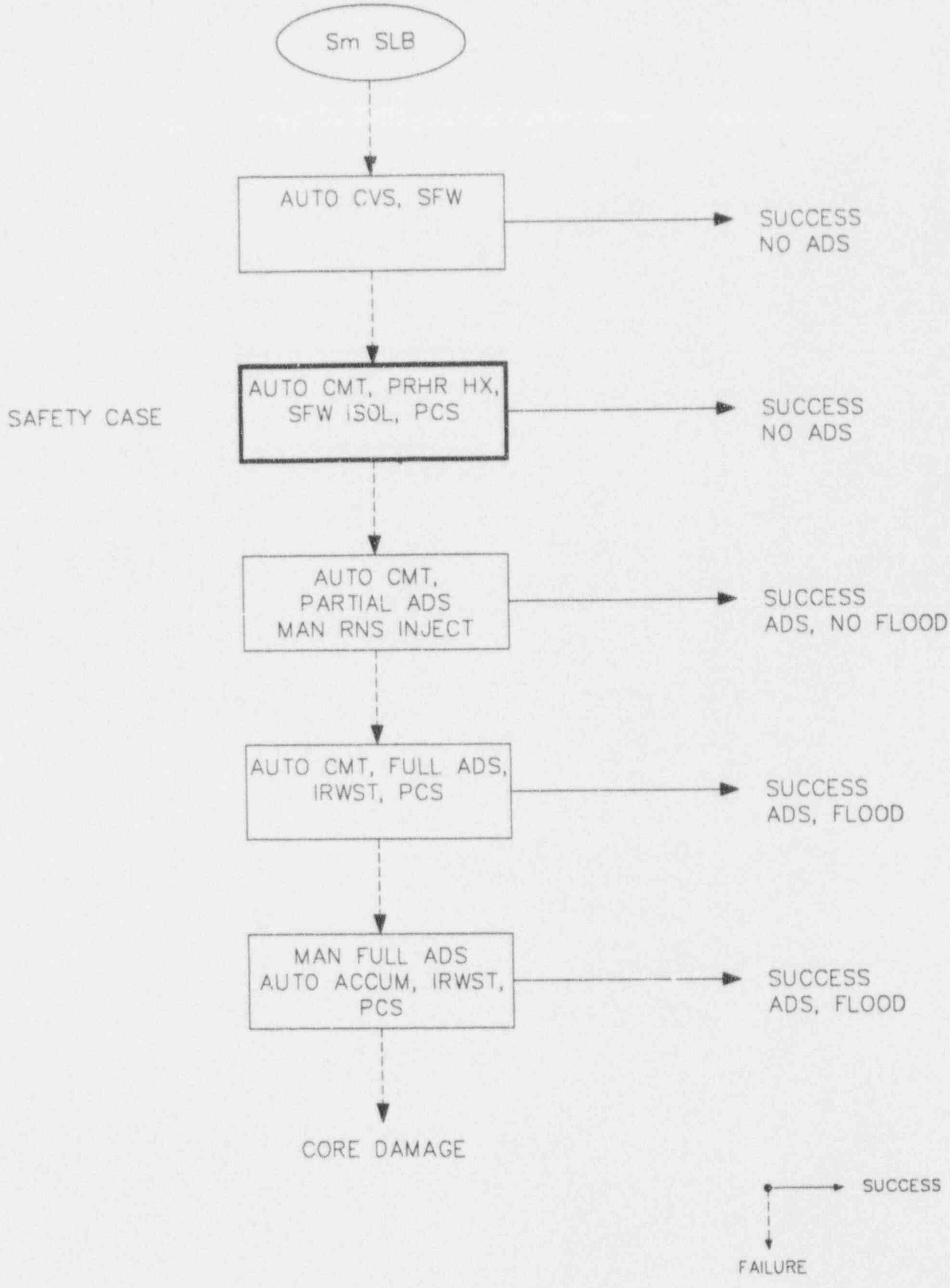


FIGURE 3.1-4: SMALL STEAM LINE BREAK AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
3. Ride Out (2)	M	Yes	Yes	-	-	A
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT	-	-	-	A	-	-
3. CMT	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW	A	Yes	Yes	-	-	-
2. PRHR HX	-	-	-	A	-	-
3. PRHR HX	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual CMT or CVS boration.

TABLE 3.1-4: SMALL STEAM LINE BREAK AT FULL POWER ACTUATION

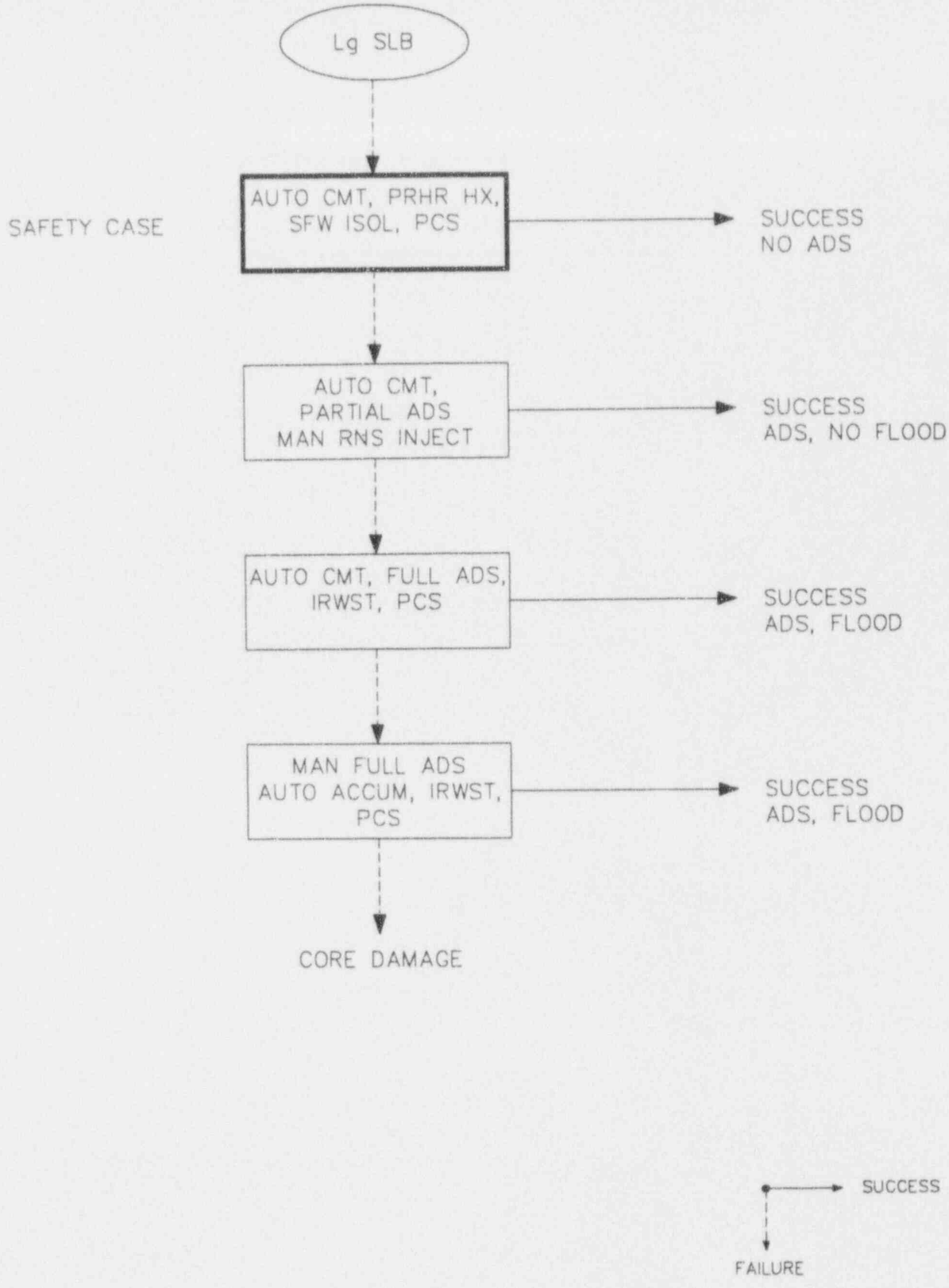


FIGURE 3.1-5: LARGE STEAM LINE BREAK AT FULL POWER FLOW CHART

Function / System Order of Use	Non-Safety PLS	Non-Safety DC	Non-Safety AC	Safety PMS	Safety DC	Diverse DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
3. Ride Out (2)	M	Yes	Yes	-	-	A
o RCS Inventory Control						
1. CMT	-	-	-	A	-	-
2. CMT	-	-	-	-	-	A
3. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	-	Yes	M
6. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
7. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. PRHR HX	-	-	-	A	-	-
2. PRHR HX	-	-	-	-	-	A
3. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	-	Yes	M
6. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
7. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air, water drain	-	-	-	-	-	A
3. CV external water fire sys only	M	Yes	Yes	-	-	-
4. CV external air only	-	-	-	-	-	-

Actuation / Electrical Systems

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

2) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual CMT or CVS boration.

TABLE 3.1-5: LARGE STEAM LINE BREAK AT FULL POWER ACTUATION

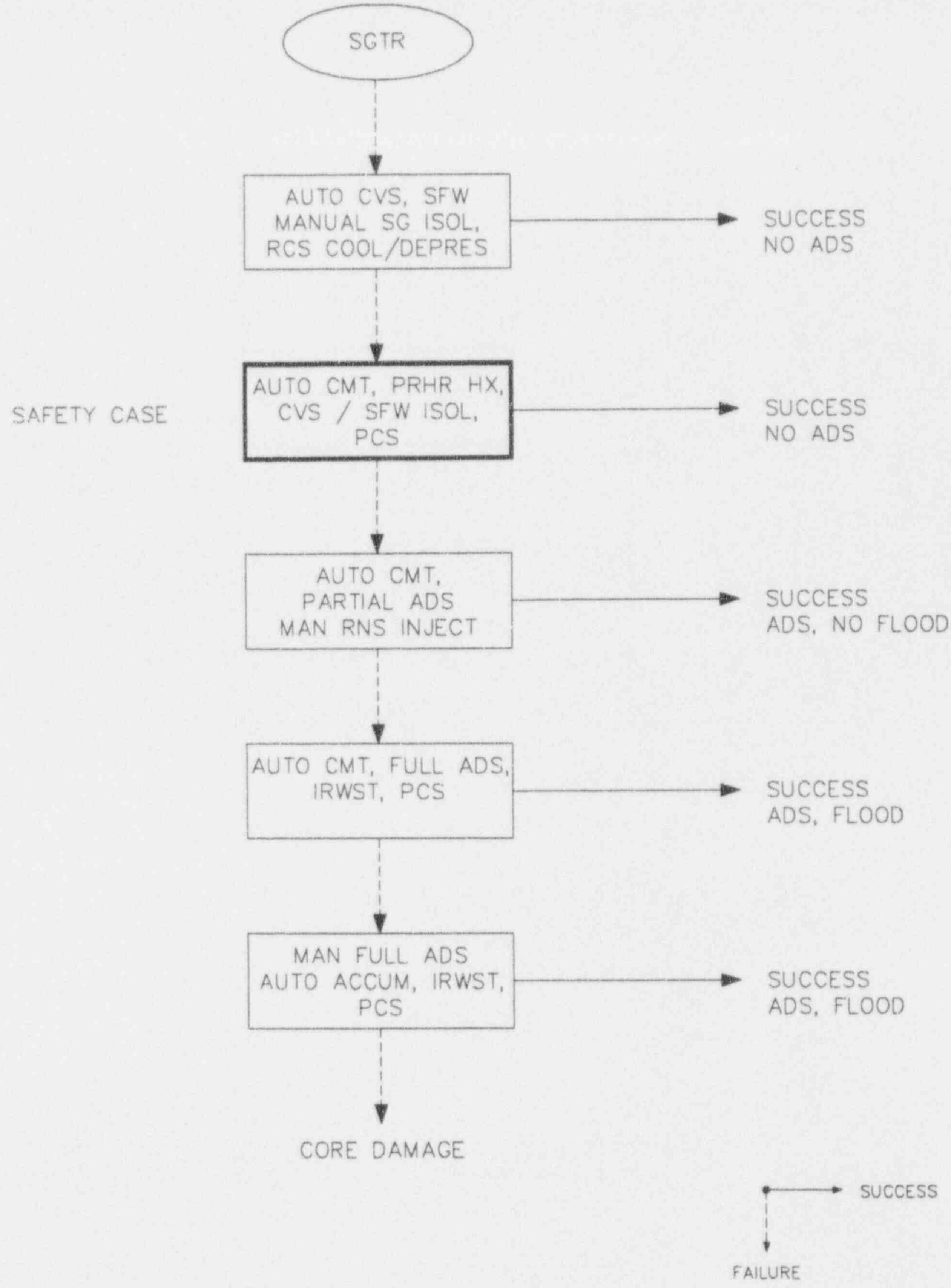


FIGURE 3.1-6: STEAM GENERATOR TUBE RUPTURE AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
o RCS Inventory Control						
1. CVS, SG isolation	A	Yes	Yes	M	-	-
2. CMT, CVS isolation	-	-	-	A	Yes	-
3. CMT, CVS isolation	M	Yes	-	-	Yes	M
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW	A	Yes	Yes	-	-	-
2. PRHR HX, SFW isolation	-	-	-	A	Yes	-
3. PRHR HX, SFW isolation	M	Yes	-	-	Yes	M
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
7. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
8. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

TABLE 3.1-6: STEAM GENERATOR TUBE RUPTURE AT FULL POWER ACTUATION

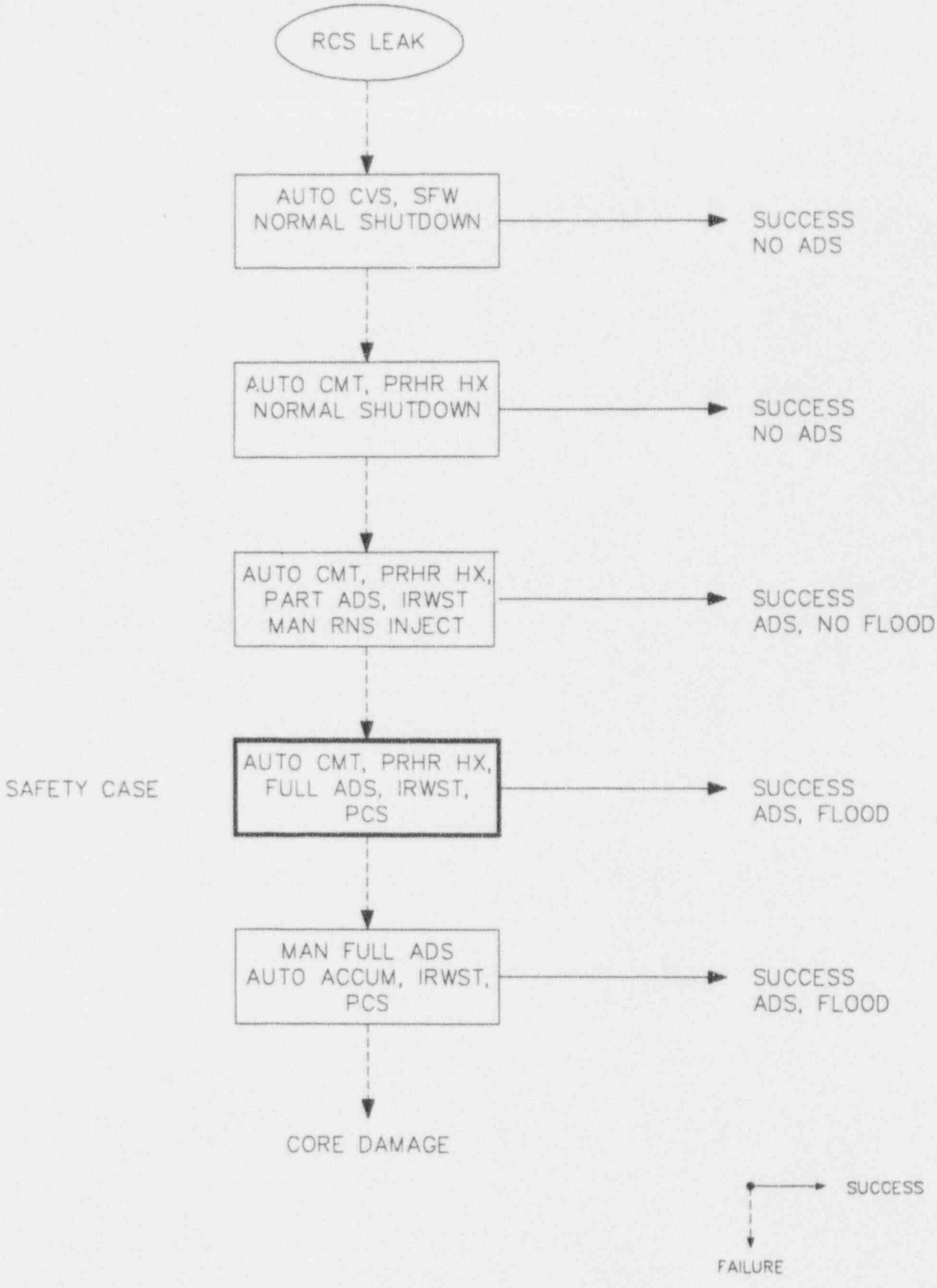


FIGURE 3.1-7: RCS LEAK (0 TO 3/8") AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1 Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
3. Ride Out (2)	M	Yes	Yes	-	-	A
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
3. CMT, IRWST, full ADS	-	-	-	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	-	Yes	M
5. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
6. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW	A	Yes	Yes	-	-	-
2. PRHR HX	-	-	-	A	-	-
3. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	-	Yes	M
6. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
7. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

2) Reactor is shut down by negative moderator temperature coefficient as the coolant heats up. Requires automatic RCS pressure relief, turbine trip, and PRHR HX actuation. Also requires manual CMT or CVS boration.

TABLE 3.1-7: RCS LEAK (0 TO 3/8") AT FULL POWER ACTUATION

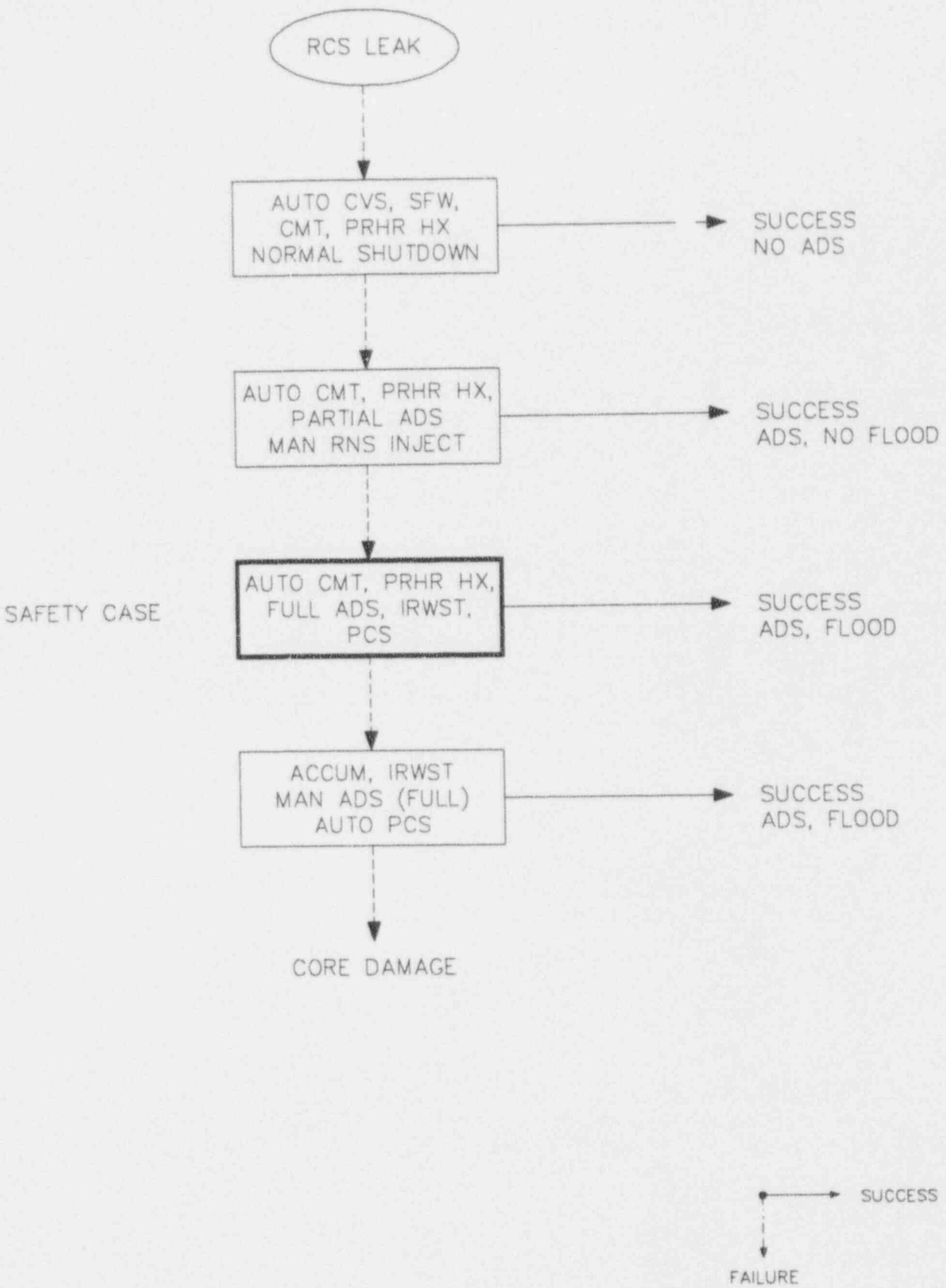


FIGURE 3.1-8: RCS LEAK (3/8" TO 1") AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
o RCS Inventory Control						
1. CVS, RNS	M	Yes	Yes	-	-	-
2. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
3. CMT, IRWST, full ADS	-	-	-	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	-	Yes	M
5. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
6. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. SFW, PRHR HX	A	Yes	Yes	M	-	-
2. PRHR HX	-	-	-	A	-	-
3. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
4. CMT, IRWST, full ADS	-	-	-	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	-	Yes	M
6. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
7. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air, water drain	-	-	-	-	-	A
3. CV external water fire sys only	M	Yes	Yes	-	-	-
4. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

TABLE 3.1-8: RCS LEAK (3/8" TO 1") AT FULL POWER ACTUATION

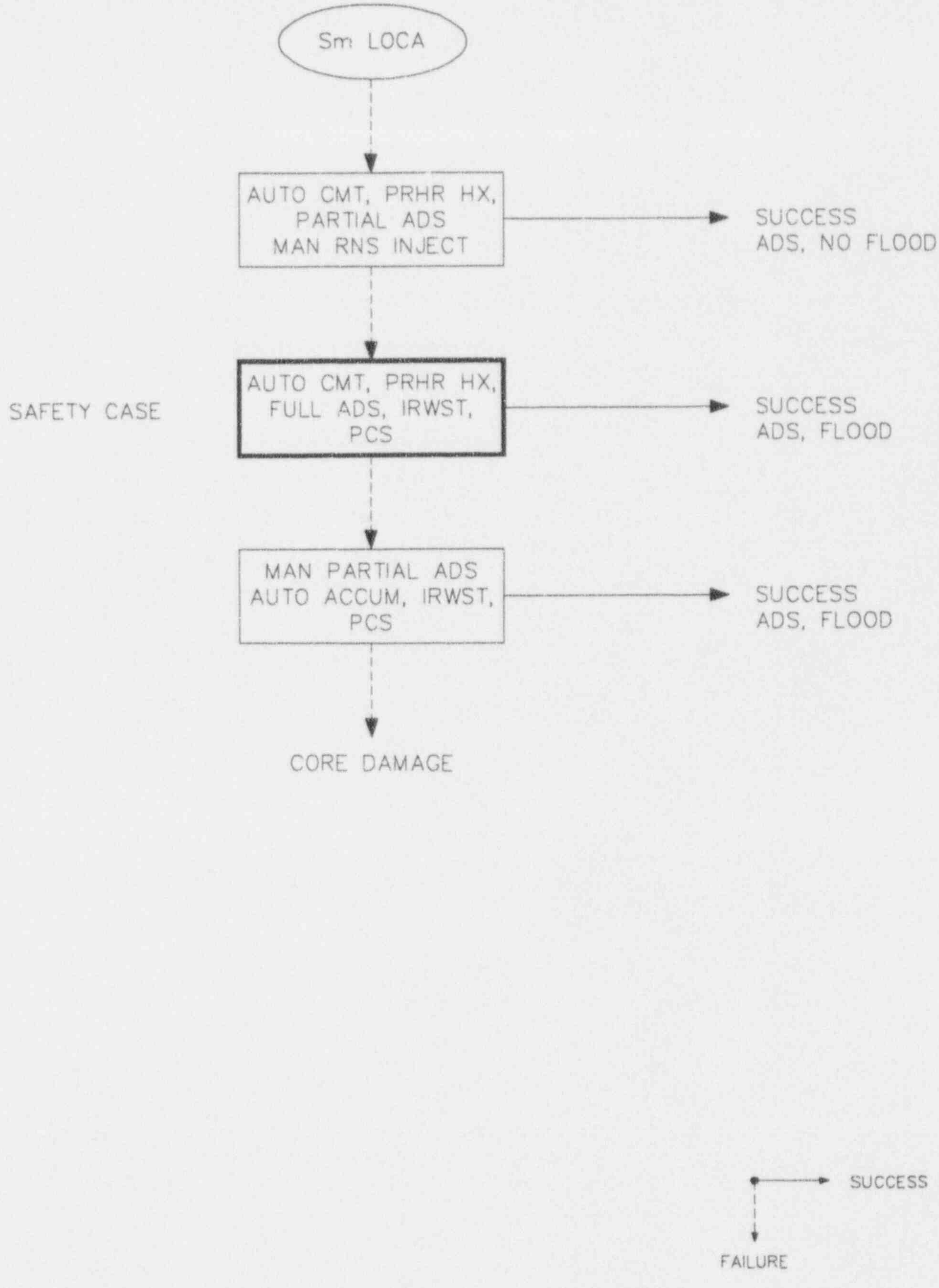


FIGURE 3.1-9: SMALL LOCA (1" TO 10") AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
2. Control Rods	-	-	-	-	-	A
o RCS Inventory Control						
1. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
2. CMT, IRWST, full ADS	-	-	-	A	Yes	-
3. CMT, IRWST, full ADS	-	-	-	-	Yes	M
4. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
5. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
2. CMT, IRWST, full ADS	-	-	-	A	Yes	-
3. CMT, IRWST, full ADS	-	-	-	-	Yes	M
4. Accum, RNS, part ADS	M	Yes	Yes	M	Yes	-
5. Accum, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air, water drain	-	-	-	-	-	A
3. CV external water fire sys only	M	Yes	Yes	-	-	-
4. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

TABLE 3.1-9: SMALL LOCA (1" TO 10") AT FULL POWER ACTUATION

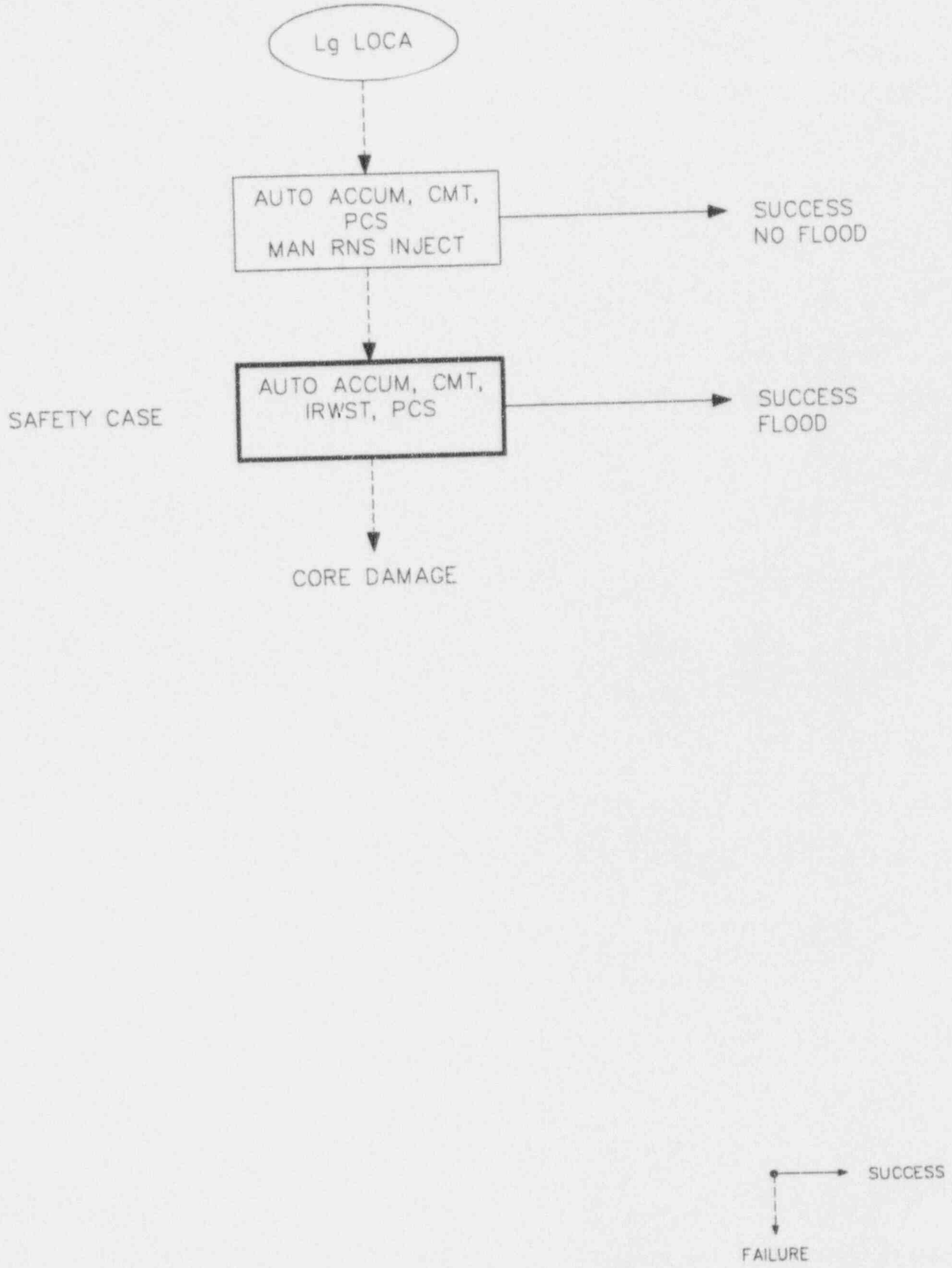


FIGURE 3.1-10: LARGE LOCA (>10") AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o **Reactor Shutdown**						
1. Voids, Boron Injection (2)	-	-	-	-	-	-
o **RCS Inventory Control**						
1. Accum, CMT, RNS (no ADS)	M	Yes	Yes	A	Yes	-
2. Accum, CMT, IRWST (no ADS)	-	-	-	A	Yes	-
3. Accum, CMT, IRWST (no ADS)	-	-	-	-	-	A
o **RCS Heat Removal**						
1. Accum, CMT, RNS (no ADS)	M	Yes	Yes	A	Yes	-
2. Accum, CMT, IRWST (no ADS)	-	-	-	A	Yes	-
3. Accum, CMT, IRWST (no ADS)	-	-	-	-	-	A
o **Containment Cooling**						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air, water drain	-	-	-	-	-	A
3. CV external water fire sys only	M	Yes	Yes	-	-	-
4. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Voiding in core provides initial shutdown, boron from PXS provides long term shutdown.

TABLE 3.1-10: LARGE LOCA (>10") AT FULL POWER ACTUATION

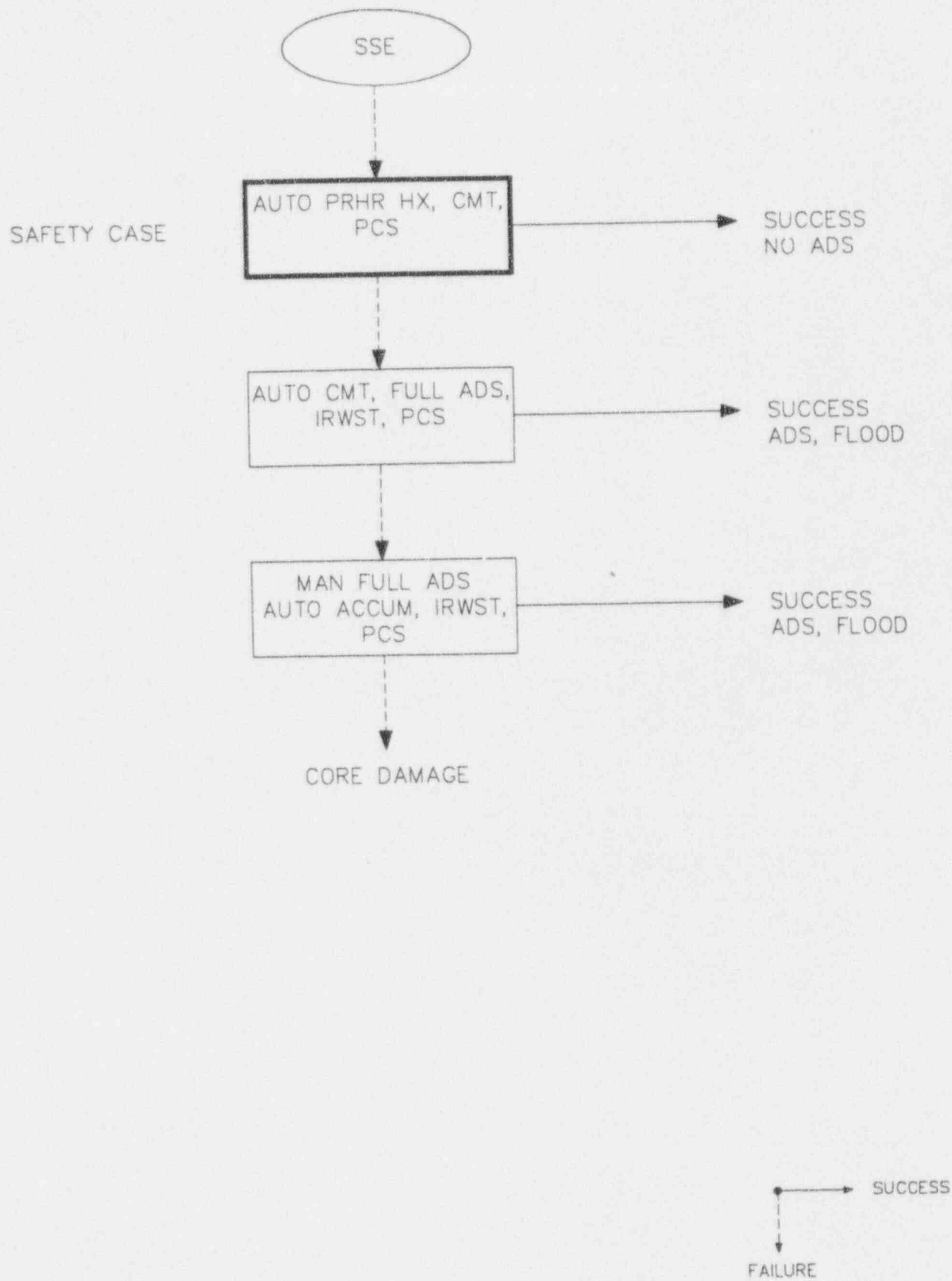


FIGURE 3.1-11: EARTHQUAKE (SSE) AT FULL POWER FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods	-	-	-	A	-	-
o RCS Inventory Control						
1. CMT	-	-	-	A	-	-
2. CMT, IRWST, full ADS	-	-	-	A	Yes	-
o RCS Heat Removal						
1. PRHR HX	-	-	-	A	-	-
2. CMT, IRWST, full ADS	-	-	-	A	Yes	-
o Containment Cooling						
1. CV external air, water drain	-	-	-	A	-	-
2. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.

TABLE 3.1-11: EARTHQUAKE (SSE) AT FULL POWER ACTUATION

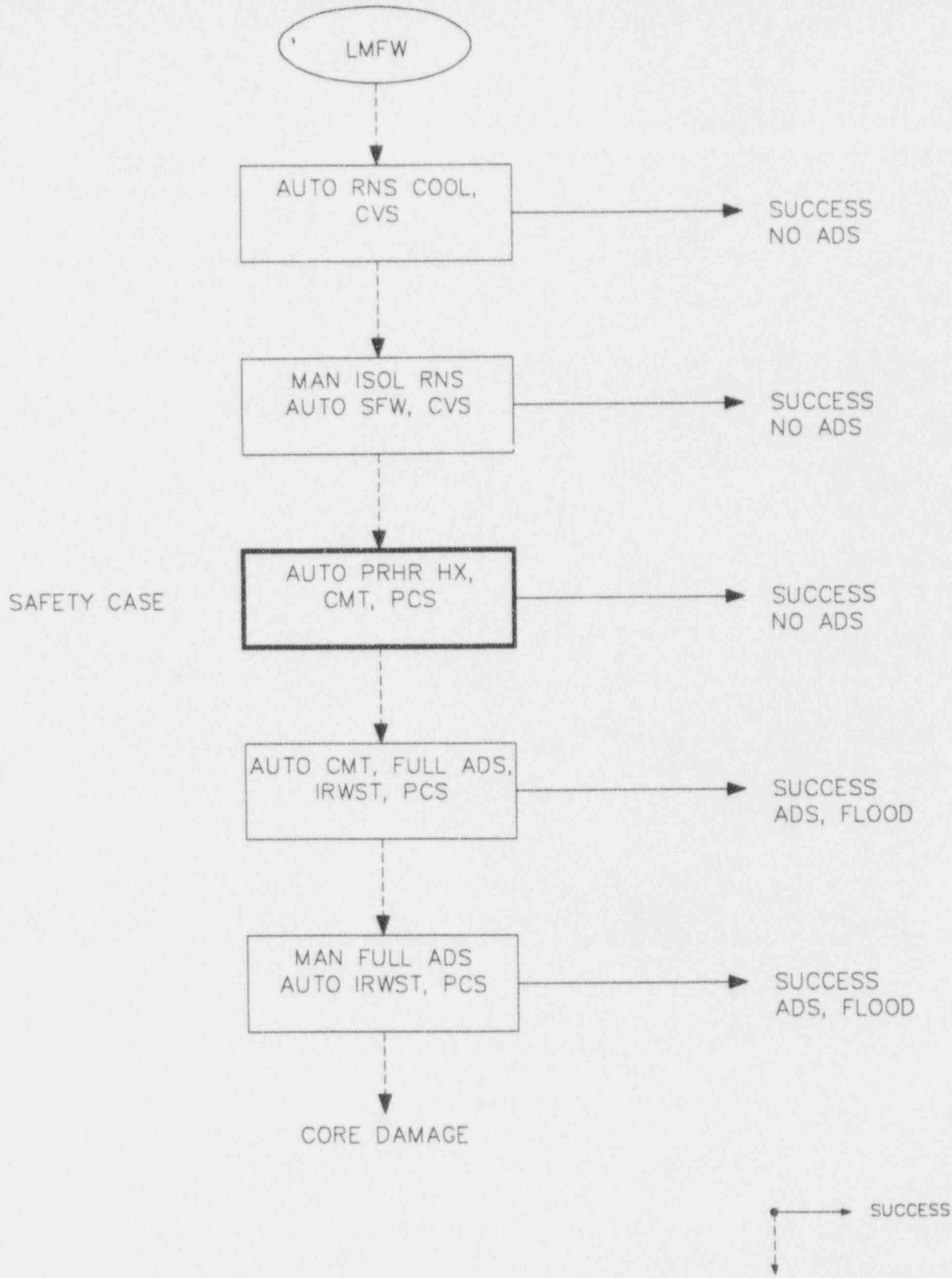


FIGURE 3.2-1: LOSS OFFSITE POWER AT HOT SHUTDOWN FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods (2)	-	-	-	-	-	-
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT	-	-	-	A	-	-
3. CMT	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	-	Yes	M
o RCS Heat Removal						
1. RNS closed loop cooling	A	Yes	Yes	-	-	-
2. SFW (isol RNS)	M	Yes	Yes	M	Yes	-
3. PRHR HX	-	-	-	A	-	-
4. PRHR HX	-	-	-	-	-	M
5. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	A	Yes	-
7. CMT, IRWST, full ADS	-	-	-	-	Yes	M
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.

TABLE 3.2-1: LOSS OFFSITE POWER AT HOT SHUTDOWN ACTUATION

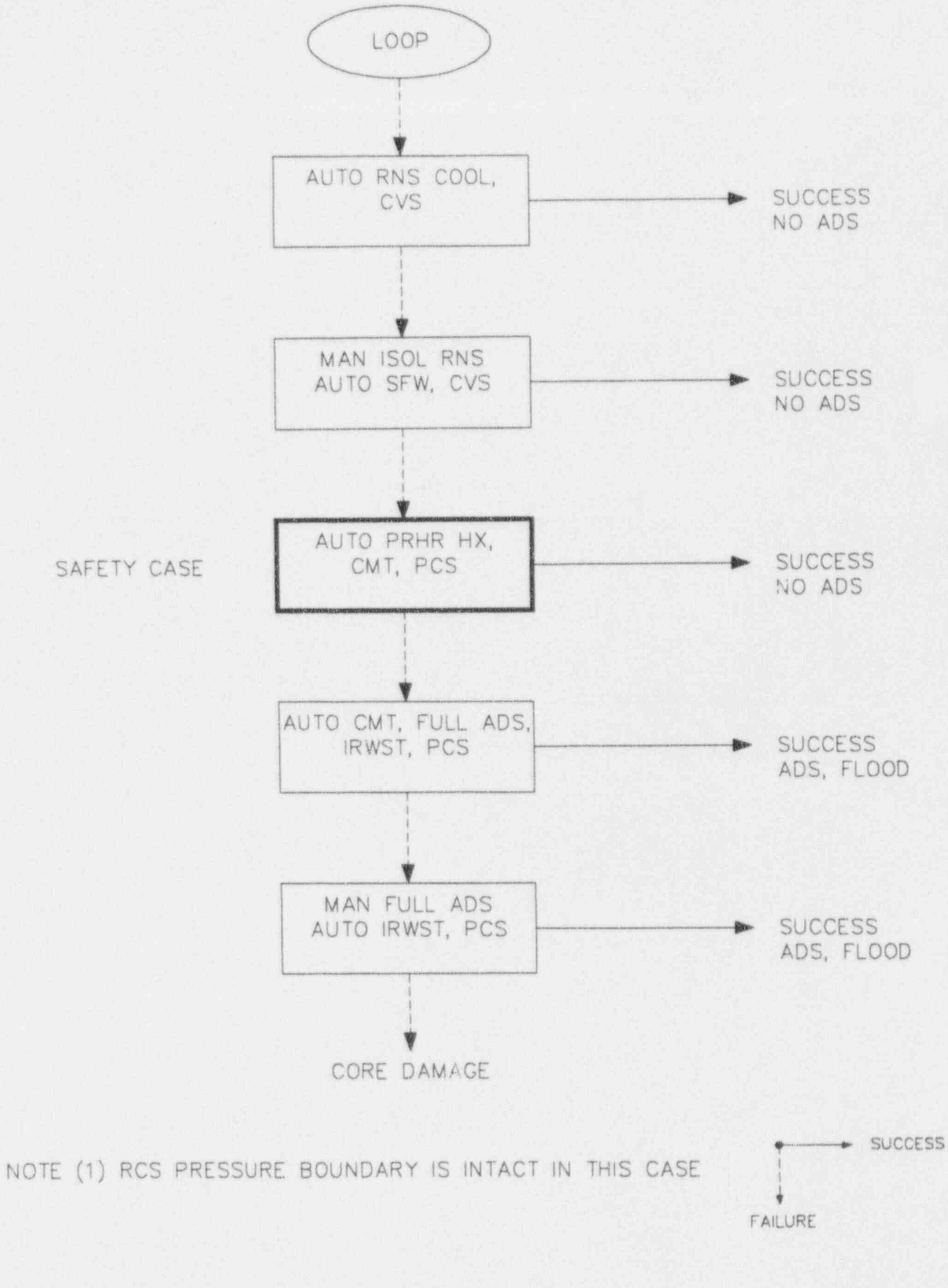
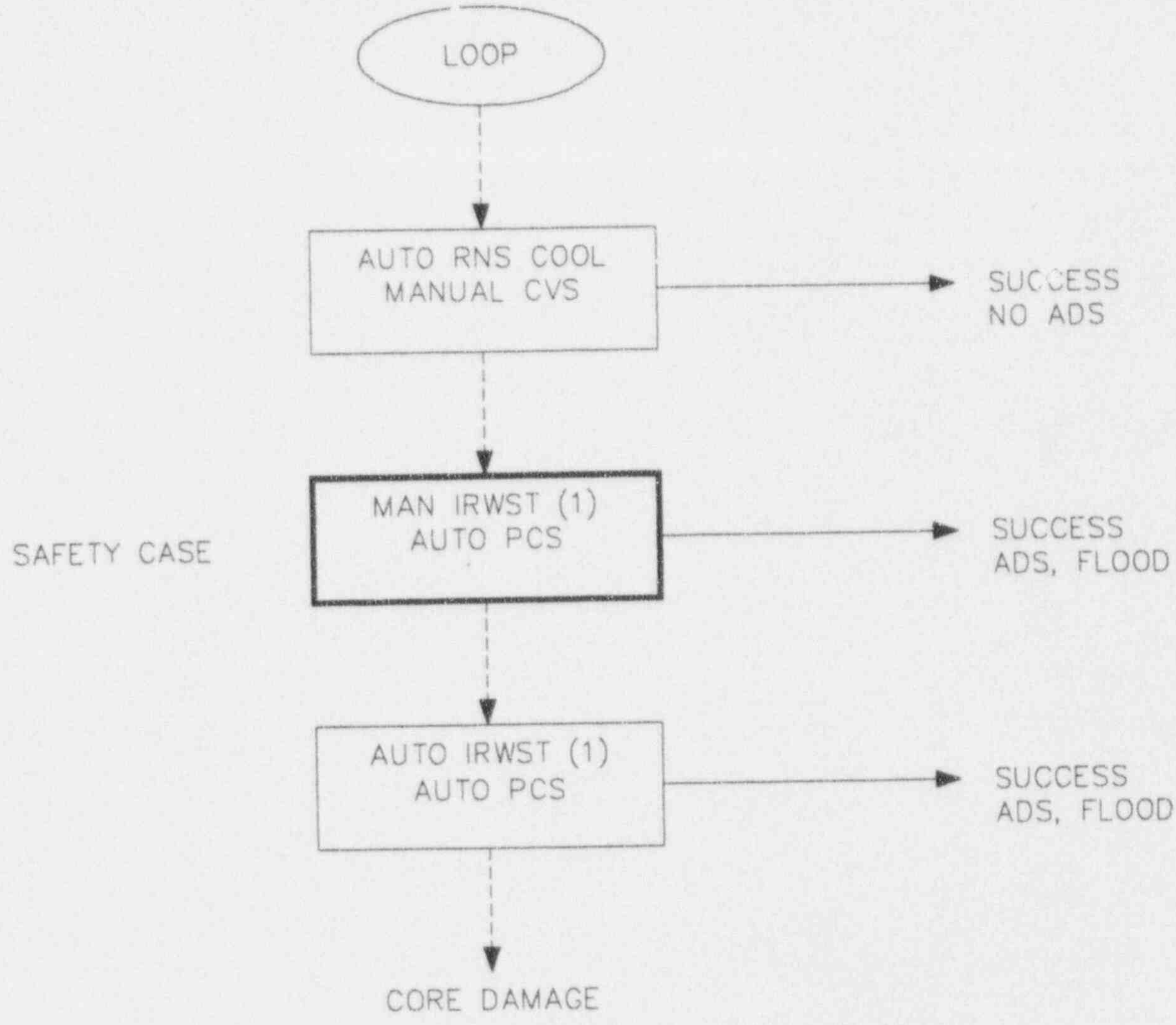


FIGURE 3.2-2: LOSS OFFSITE POWER AT COLD SHUTDOWN FLOW CHART (1)

Function System Order of Use	Actuation / Electrical Systems: Non-Safety PLS	Non-Safety DC	Non-Safety AC	Safety PMS	Safety DC	Diverse DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods (2)	-	-	-	-	-	-
o RCS Inventory Control						
1. CVS	A	Yes	Yes	-	-	-
2. CMT	-	-	-	A	-	-
3. CMT	-	-	-	-	-	A
4. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
5. CMT, IRWST, full ADS	-	-	-	A	Yes	-
7. CMT, IRWST, full ADS	-	-	-	-	Yes	M
8. IRWST, full ADS	-	-	-	M	Yes	-
o RCS Heat Removal						
1. RNS closed loop cooling	A	Yes	Yes	-	-	-
2. SFW (isol RNS)	M	Yes	Yes	M	Yes	-
3. PRHR HX	-	-	-	A	-	-
4. PRHR HX	-	-	-	-	-	M
5. CMT, RNS, part ADS	M	Yes	Yes	A	Yes	-
6. CMT, IRWST, full ADS	-	-	-	A	Yes	-
7. CMT, IRWST, full ADS	-	-	-	-	Yes	M
8. IRWST, full ADS	-	-	-	M	Yes	-
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.

TABLE 3.2-2: LOSS OFFSITE POWER AT COLD SHUTDOWN ACTUATION



NOTE (1) ADS STAGES 1,2,3 WILL BE OPEN DURING MID-LOOP

FIGURE 3.2-3: LOSS OFFSITE POWER AT MID-LOOP FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods (2)	-	-	-	-	-	-
o RCS Inventory Control						
1. CVS	M	Yes	Yes	-	-	-
2. CMT	-	-	-	M	-	-
3. CMT	-	-	-	-	-	M
4. RNS injection (3)	M	Yes	Yes	-	-	-
5. IRWST (3)	-	-	-	M	Yes	-
6. IRWST (3)	-	-	-	-	Yes	A
o RCS Heat Removal						
1. RNS closed loop cooling	A	Yes	Yes	-	-	-
2. RNS injection (3)	M	Yes	Yes	-	-	-
3. IRWST (3)	-	-	-	M	Yes	-
4. IRWST (3)	-	-	-	-	Yes	
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:

1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.
3) ADS stages 1,2,3 are required by tech spec to be open during mid-loop operation.

TABLE 3.2-3: LOSS OFFSITE POWER AT MID-LOOP ACTUATION

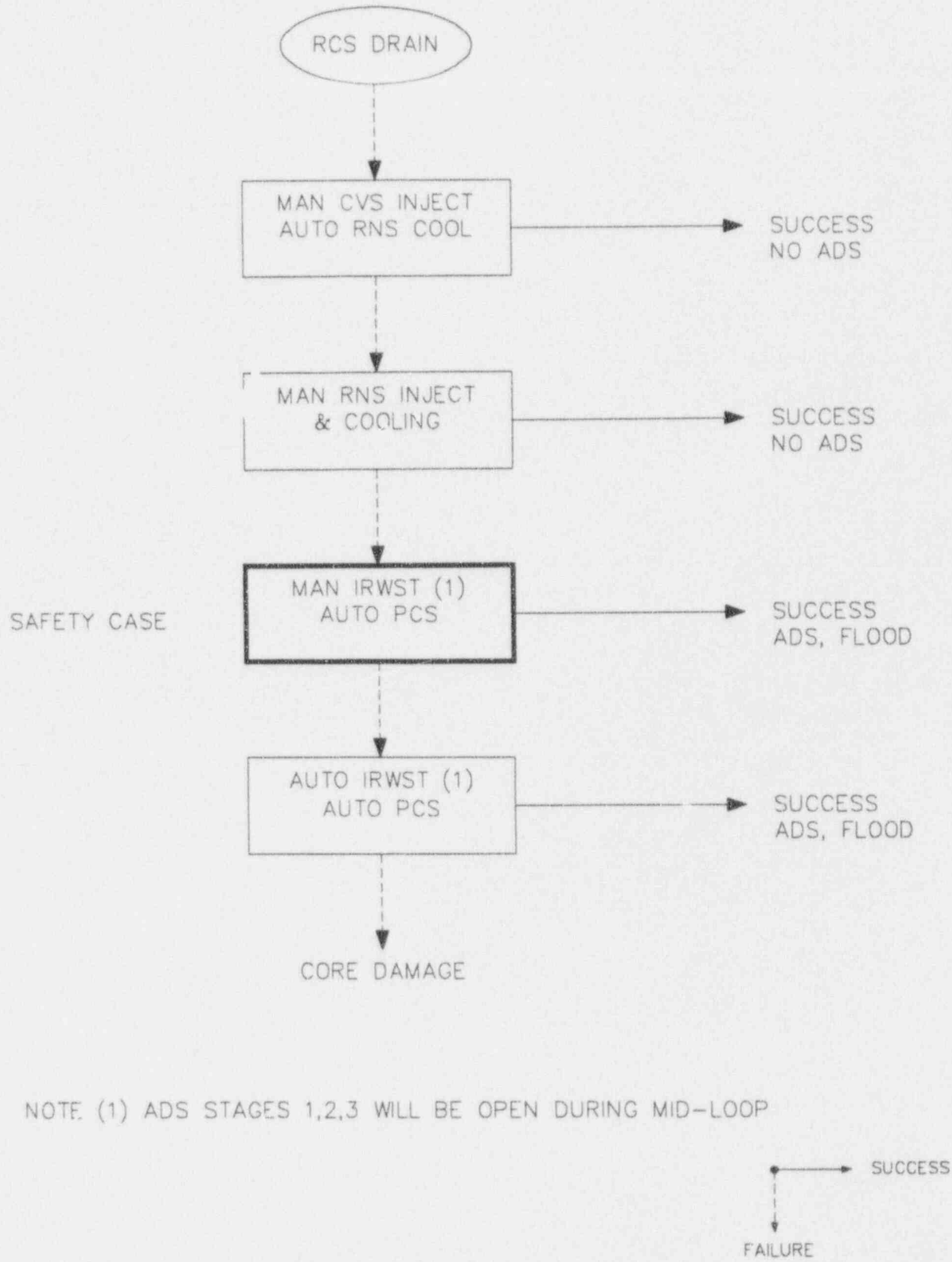
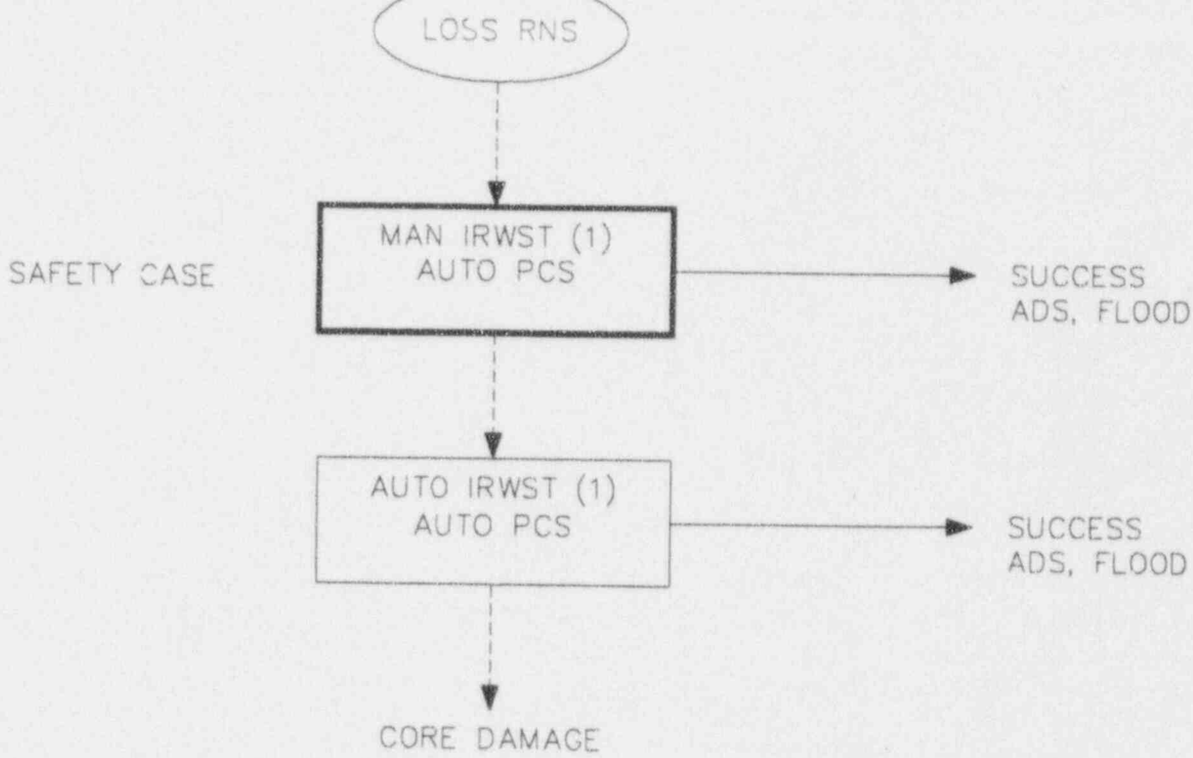


FIGURE 3.2-4: INADVERTENT RCS DRAIN AT MID-LOOP FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o Reactor Shutdown						
1. Control Rods (2)	-	-	-	-	-	-
o RCS Inventory Control						
1. CVS	M	Yes	Yes	-	-	-
2. CMT	-	-	-	M	-	-
3. CMT	-	-	-	-	-	M
4. RNS injection (3)	M	Yes	Yes	-	-	-
5. IRWST (3)	-	-	-	M	Yes	-
6. IRWST (3)	-	-	-	-	Yes	A
o RCS Heat Removal						
1. RNS injection (3)	M	Yes	Yes	-	-	-
2. IRWST (3)	-	-	-	M	Yes	-
3. IRWST (3)	-	-	-	-	Yes	A
o Containment Cooling						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.
3) ADS stages 1,2,3 are required by tech spec to be open during mid-loop operation.

TABLE 3.2-4: INADVERTENT RCS DRAIN AT MID-LOOP ACTUATION



NOTE (1) ADS STAGES 1,2,3 WILL BE OPEN DURING MID-LOOP

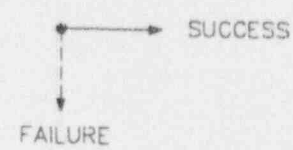


FIGURE 3.2-5: LOSS RNS AT MID-LOOP FLOW CHART

Function System Order of Use	Non-Safety			Safety		Diverse
	Actuation / Electrical Systems					
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o **Reactor Shutdown**						
1. Control Rods (2)	-	-	-	-	-	-
o **RCS Inventory Control**						
1. CVS	M	Yes	Yes	-	-	-
2. CMT	-	-	-	M	-	-
3. CMT	-	-	-	-	-	M
4. IRWST (3)	-	-	-	M	Yes	-
5. IRWST (3)	-	-	-	-	Yes	A
o **RCS Heat Removal**						
1. IRWST (3)	-	-	-	M	Yes	-
2. IRWST (3)	-	-	-	-	Yes	A
o **Containment Cooling**						
1. Fan Coolers	A	Yes	Yes	-	-	-
2. CV external air, water drain	-	-	-	A	-	-
3. CV external air, water drain	-	-	-	-	-	A
4. CV external water fire sys only	M	Yes	Yes	-	-	-
5. CV external air only	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.
3) ADS stages 1,2,3 are required by tech spec to be open during mid-loop operation.

TABLE 3.2-5: LOSS RNS AT MID-LOOP ACTUATION

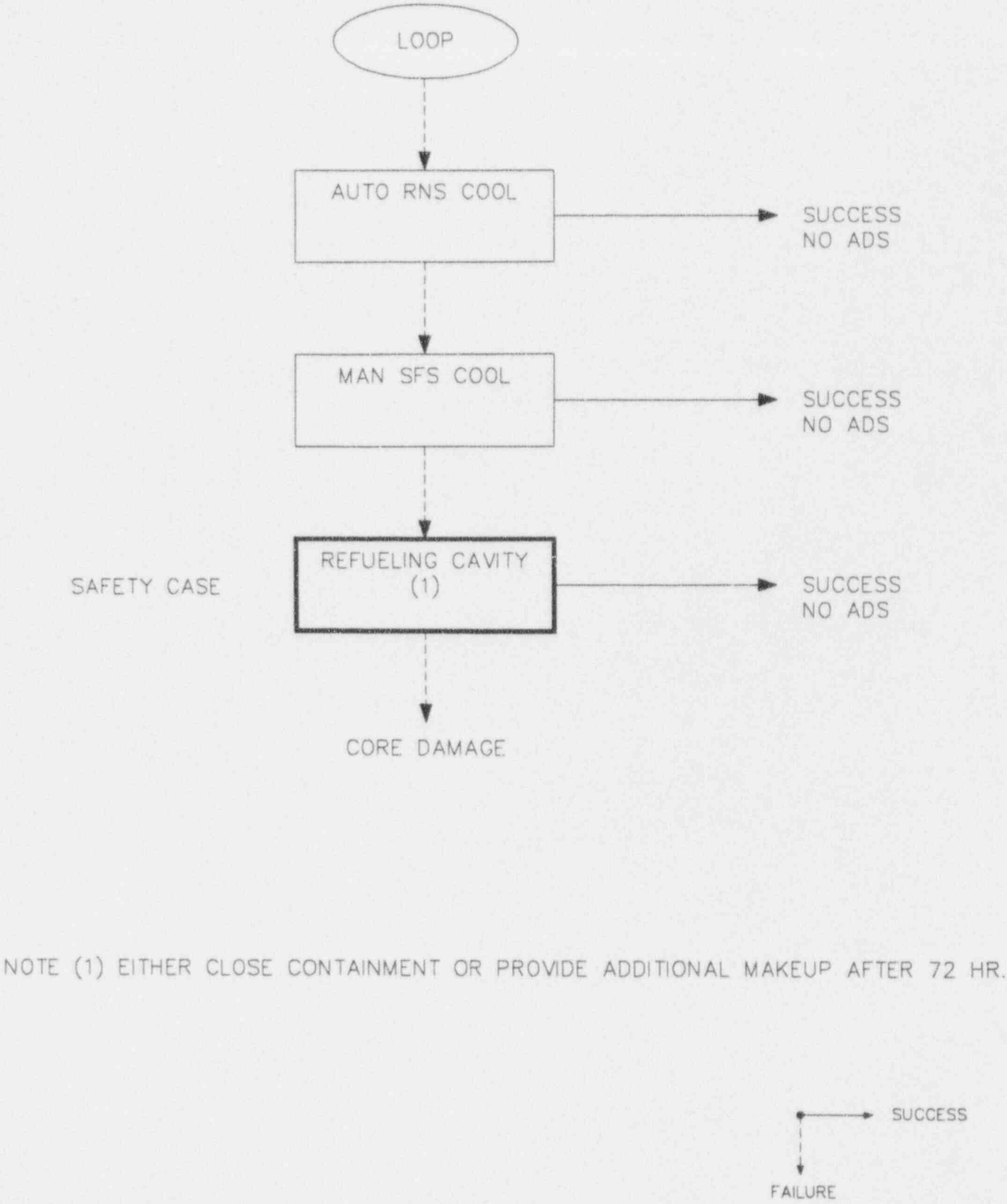


FIGURE 3.2-6: LOSS OFFSITE POWER AT REFUELING FLOW CHART

Function System Order of Use	Actuation / Electrical Systems					
	Non-Safety			Safety		Diverse
	PLS	DC	AC	PMS	DC	DAS
	(1)			(1)		(1)
o **Reactor Shutdown**						
1. Control Rods (2)	-	-	-	-	-	-
o **RCS Inventory Control**						
1. CVS	M	Yes	Yes	-	-	-
2. SFS Injection	M	Yes	Yes	-	-	-
3. Refueling Cavity Inventory (3)	-	-	-	-	-	-
o **RCS Heat Removal**						
1. RNS closed loop cooling	A	Yes	Yes	-	-	-
2. SFS cooling (refueling cavity)	M	Yes	Yes	-	-	-
3. Refueling Cavity Inventory (3)	-	-	-	-	-	
o **Containment Cooling**						
1. Containment open (3)	-	-	-	-	-	-

Notes:
1) Manual controls are provided. The PLS has nonsafety-related MCB soft control switches. The PMS has safety-related MCB manual controls via both individual soft control switches and dedicated system level switches. The DAS has MCB manual controls via dedicated switches.
2) Control rods are inserted and the RCS borated prior to the event.
3) Containment can be closed or additional makeup provided after 72 hours.

TABLE 3.2-6: LOSS OFFSITE POWER AT REFUELING ACTUATION

4.0 DEFINITIONS AND ABBREVIATIONS

A or Auto	Automatic actuation
AC	Alternating Current electrical power
Accum	Accumulator (safety)
ADS	Automatic Depressurization Valves (safety)
ADS (part)	Sufficient ADS valves to allow RNS injection, Stage 1, 2 & 3 (safety)
ADS (full)	Sufficient ADS valves to allow gravity drain from IRWST, Stage 4 (safety)
AMSAC	ATWS Mitigation System Actuation Circuitry
ATWS	Anticipated Transient Without Scram
BAT	Boric Acid Tank (nonsafety)
CCS	Containment Cooling System (safety)
CMT	Core Makeup Tank (safety)
CV	Containment Vessel, used for passive cooling (safety)
CVS	Chemical and Volume Control System (nonsafety)
DAS	Diverse Actuation System (nonsafety)
DC	Direct Current electrical power
EOP	Emergency Operating Procedures
IRWST	In-containment Refueling Water Storage Tank (safety)
M or Man	Manual actuation
MMI	Man Machine Interface
RNS	Normal Residual Heat Removal System (nonsafety)
PCS	Passive Containment Cooling System (safety)
PLS	Plant Control System (nonsafety)
PRA	Probabilistic Risk Assessment
PRHR HX	Passive Residual Heat Removal Heat Exchanger (safety)
PMS	Protection and Safety Monitoring System (safety)
Pzr	Pressurizer
RCP	Reactor Coolant Pumps
RCS	Reactor Coolant System (safety)
S signal	Safeguards Actuation Signal
SFW	Startup Feedwater System (nonsafety)
SG	Steam Generator
SSD	System Specification Documents
TS	Technical Specifications