7.3 Engineered Safety Feature Systems, Instrumentation and Control

The information in this section of the reference ABWR DCD, including all subsections and figures, is incorporated by reference with the following departures and supplements.

STD DEP T1 2.3-1 (Figure 7.3-5)

STD DEP T1 2.4-1 (Figure 7.3-4)

STD DEP T1 2.4-2

STD DEP T1 2.4-3 (Figures 7.3-3, 7.3-4)

STD DEP T1 2.14-1 (Figures 7.3-4, 7.3-5)

STD DEP T1 3.4-1 (Figures 7.3-1, 7.3-2, 7.3-3, 7.3-5)

STP DEP 1.1-2

STD DEP 1.8-1

STD DEP 7.1-1

STD DEP 7.3-1 (Figure 7.3-1)

STD DEP 7.3-2

STD DEP 7.3-4 (Figure 7.3-2)

STD DEP 7.3-5

STD DEP 7.3-6 (Figure 7.3-2)

STD DEP 7.3-7 (Figure 7.3-7)

STD DEP 7.3-9

STD DEP 7.3-10 (Figures 7.3-1, 7.3-4)

STD DEP 7.3-11

STD DEP 7.3-12

STD DEP 7.3-13 (Figure 7.3-4)

STD DEP 7.3-14 (Figure 7.3-4)

STD DEP 7.3-15

STD DEP 7.3-16

STD DEP 7.3-17

STD DEP 7.3-18 (Figures 7.3-1, 7.3-2)

STD DEP 7.7-2

STD DEP Admin (Figure 7.3-5)

7.3.1 Description

7.3.1.1 System Descriptions

STD DEP 1.8-1

This subsection describes the instrumentation and controls for the various engineered safety features (ESF) systems. It provides design basis information as called for by IEEE- 279 603 and provides reference to system diagrams which are included in the Safety Analysis Report.

7.3.1.1.1.1 High Pressure Core Flooder System Instrumentation and Controls

STD DEP T1 3.4-1

STD DEP 7.1-1

STD DEP 7.3-1

STD DEP Admin

(2) Supporting Systems (Power Supplies)

Supporting systems for the HPCF I&C consist only of the instrumentation, logic and motive power supplies. The controls instrumentation and logic power is obtained from the SSLC ESF Logic and Control (ELCS) *Division 2 and 3, 120 VAC UPS buses (Section 8.3). The logic power is as described in Section 7.2 for the RPS portion of the SSLC* Reactor Trip and Isolation System (RTIS)*.*

(3) *Equipment Design*

(a) *(w)Initiating Circuits*

Reactor vessel low water level is monitored by four level transmitters (one in each of the four electrical divisions) that sense the difference between the pressure due to a constant reference leg of water and the pressure due to the actual height of water in the vessel. Each level transmitter provides an input to local multiplexer units which perform signal conditioning and a remote digital logic controller (RDLC) for *analog-to-digital conversion. The formatted, digitized sensor input is* transmitted *with other sensor signals over an optical fiber data link to the logic processing units in the main control room. All four transmitter* *signals are fed into the two-out-of-four logic for each of the two divisions (II & III). The initiation logic for HPCF sensors is shown in Figure 7.3-1.*

The HPCF System is initiated on receipt of a reactor vessel low water level signal (Level 1.5) or drywell high-pressure signal from the trip logic. The HPCF System reaches its design flow rate ~~within 36 seconds of receipt of initiation signal~~ in a time interval consistent with Table 6.3-1*. Makeup water is discharged to the reactor vessel until the reactor high water level is reached. The HPCF System then automatically stops flow by closing the injection valve if the high water level signal is available.*

(d) Redundancy and Diversity

The following standard supplement provides reference to additional information.

For additional diverse HPCF features to mitigate potental common-mode failure conditions, see the discussion in Subsection 7C.5.

(e) Actuated Devices

The HPCF valves must be opened sufficiently to provide design flow rate within ~~36 seconds from receipt of the initiation signal~~ the time interval consistent with Table 6.3-1.

(f) Separation

Separation within the ECCS is such that no single design basis event, in conjunction with an additional single failure, can prevent core cooling when required. Control and electrically driven equipment wiring is segregated into three separate electrical divisions, designated I, II and III (Figure 8.3-1). Initiation sensor inputs are from all four divisions. *HPCF is a two-division system utilizing Divisions II and III. HPCF control logic, cabling, manual controls and instrumentation are arranged such that divisional separation is maintained. System separation and diesel loading are shown in Table 8.3-1.*

(g) Testability

The high-pressure core flooder (HPCF) instrumentation and control system is capable of being tested during normal unit operation to verify the operability of each system component. Testing of the initiation transmitters which are located outside the drywell is accomplished by valving out each transmitter, one at a time, and applying a test pressure source. This verifies the operability of the transmitter, as well as the calibration range. The analog sensor inputs are calibrated at the analog inputs of the ~~remote~~ ~~multiplexing units~~ RDLCs*. With a division-of-sensors bypass in place, calibrated, variable signals are injected in* *place of the sensor signals and monitored at the ~~SSLC~~ ELCS control room panels for linearity, accuracy, fault response, and downscale and upscale trip response.*

(i) Operational Considerations

~~*See Chapter 16 for setpoints and margins.*~~The Bases for Chapter 16 describe the methods for calculating setpoints and margins.

7.3.1.1.1.2 Automatic Depressurization Subsystem Instrumentation and Controls

STD DEP T1 3.4-1

STD DEP 7.1-1

STD DEP 7.3-2

STD DEP 7.3-4

STD DEP 7.3-5

STD DEP 7.3-6

STD DEP 7.3-7

STD DEP 7.3-16

STD DEP 7.7-2

STD DEP Admin

(1) System Identification

Automatic safety/relief valves (SRVs) are installed on the main steamlines inside the drywell. The valves can be actuated in two ways: (1) ~~they will relieve pressure by actuation with electrical power~~ by pneumatic action *or (2) by mechanical actuation without power. The suppression pool provides a heat sink for steam relieved by these valves. Relief valve operation may be controlled manually from the control room to hold the desired reactor pressure. Eight of the SRVs are designated as Automatic Depressurization Subsystem (ADS) valves and are capable of operating from either ADS logic or safety/relief logic signals. The safety/relief logic is discussed in Paragraph (4). Automatic depressurization by the ADS is provided to reduce the pressure during a loss-of-coolant accident in which the HPCF and RCIC Systems are unable to restore vessel water level. This allows makeup of core cooling water by the low pressure makeup system (RHR/LP flooding mode).*

(3) Equipment Design

The ADS accumulators are sized to operate the SRV one time at drywell design pressure or five times at normal drywell pressure, following failure of the pneumatic supply to the accumulator. Sensors provide inputs to ~~*local multiplexer units which perform signal conditioning and*~~ an RDLC for *analog-to-digital conversion. The formatted, digitized sensor inputs are* ~~*multiplexed*~~ transmitted *with other sensor signals over an optical data link to the logic processing units in the main control room. All four transmitter signals are fed into the two-out-of-four logic for each of two divisions, either of which can actuate the ADS. Station batteries and* ~~*SSLC*~~ ELCS *power supplies energize the electrical control circuitry. The power supplies for the redundant divisions are separated to limit the effects of electrical failures. Electrical elements in the control system energize to cause the relief valves to open.*

(a) ~~*ADS Initiating Circuits*~~

~~*The level transmitters used to initiate one ADS logic are separated from those used to initiate the other ADS logic. Reactor vessel low water level is detected by eight transmitters that measure differential pressure. Drywell high pressure is detected by four pressure transmitters. All the vessel level and drywell high-pressure transmitters are located in the Reactor Building outside the drywell. The drywell high-pressure signals are arranged to seal-in the control circuitry. They must be manually reset to clear.*~~

(b) Logic and Sequencing

Two parameters of initiation signals are used for the ADS: drywell high pressure and reactor vessel ~~*low-low*~~ *water* below ~~*level (*~~*Level 1*~~*)*~~ or reactor vessel water below Level 1 alone after a time delay. *Two-out-of-four of each set of signals must be present throughout the timing sequence to cause the SRVs to open. Each parameter separately seals itself in and annunciates following the two-out-of-four logic confirmation.* ~~*Low*~~ *Water Level 1 is the final sensor to initiate the ADS.*

After receipt of the initiation signals and after a delay provided by time delay elements, each of the two solenoid pilot gas valves is energized. This allows pneumatic pressure from the accumulator to act on the gas cylinder operator. The gas cylinder operator opens and holds the relief valve open. Lights in the main control room indicate when the ~~*solenoid-operated pilot valves are*~~ gas cylinder operator is ~~*energized to*~~ *open*ed or closed for *a safety/relief valve.* ~~Limit Switches mounted on the gas cylinder operators verify each valve position to the Performance Monitoring and Control System (PMCS), and the annunciators.~~~~*Linear variable differential transformers (LVDTs)*~~ Limit switches *mounted on the* gas cylinder ~~*valve*~~ *operators verify each valve position to the Performance Monitoring and Control System (PMCS), and the annunciators.*

Manual reset circuits are provided for the ADS initiation signal and the two parameter sensor input logic signals. An attempted reset has no effect if the two-out-of-four initiation signals are still present from each parameter (high drywell pressure and ~~low-low~~ reactor water level below Level 1*). However, ~~a keylocked~~* an *inhibit switch is provided for each division which can be used to take one ADS division out of service for testing or maintenance during plant operation. This switch is ineffective once the ADS timers have timed out and thus cannot be used to abort and reclose the valves once they are signalled to open. The inhibit mode is continuously annunciated in the main control room.*

For anticipated transient without scram (ATWS) mitigation, the ADS has an automatic and manual inhibit of the automatic ADS initiation. Automatic initiation of ADS is inhibited ~~unless there is a coincident low reactor water level signal and an average power range monitors (APRMs) ATWS permissive signal~~ whenever potential ATWS conditions exist as indicated by APRMs not being down scale*. There are main control room switches for the manual inhibit of automatic initiation of ADS.*

(c) Bypasses and Interlocks

There is one manual ADS inhibit switch in the control room for each ADS logic and control division which will inhibit ADS initiation, if ADS has not initiated. The primary purpose of the inhibit switch is to remove one of the two ADS logic and control divisions from service for testing and maintenance during plant operation. The ADS is interlocked with the HPCF and RHR Systems by means of pressure sensors located on the discharge of these pumps. Manual ADS bypasses the timers and immediately opens the ADS valves, provided the ECCS pump(s) running permissives are present. The ~~rotating collar permissives and duality of button sets~~ need to rotate the collar before depressing the pushbutton*, combined with annunciators*, *assure manual initiation of ADS to be a deliberate act.*

(d) Redundancy and Diversity

The ADS is initiated by high drywell pressure and/or ~~low~~ reactor vessel water ~~level~~ Level 1*. The initiating circuits for each of these parameters are redundant as described by the circuit description of this section. Diversity is provided by the HPCF ~~System~~* and RCIC Systems.

(f) Separation

Separation of the ADS is in accordance with criteria stated in Section 7.1. ADS is a Division I (ADS 1) and Division II (ADS 2) system, except that only one set of relief valves is supplied. Each ADS relief valve can be actuated by any one of three solenoid pilot valves supplying nitrogen gas to the relief valve gas piston operators. One of the ADS solenoid *pilot valves is operated by Division I logic and the other by Division II logic. The third solenoid pilot is used for non-ADS operation.* The non-ADS SRV function solenoid pilot valves are powered from Division I, II or III Class 1E DC bus. *Control logic manual controls and instrumentation are mounted so that Division I and Division II separation is maintained. Separation from Divisions III and IV is likewise maintained.*

(g) *Testability*

The ADS has two complete control logics, one in Division I and one in Division II. Each control logic has two circuits, both of which must operate to initiate ADS. Both circuits contain time delay logic to give the HPCF System an opportunity to restore water level. The ADS instrument channels signals are verified by cross comparison between the channels which bear a known relationship to each other. Indication for each instrument channel is available on displays associated with the ~~SSLC~~ ELCS. ~~The logic is tested continuously by automatic self-test circuits. The STS (~~SSLC testing, as described in *the sixth test*~~)~~, *discussed in RPS testability (Subsection 7.1.2.1.6) is also applicable here for the ADS. The instrument channels are* manually verified in accordance with Technical Specification requirements~~automatically verified every ten minutes~~. *Testing of ADS does not interfere with automatic operation if required by an initiation signal. The pilot solenoid valves can* also *be tested*~~.~~ ~~when the reactor is not pressurized~~.

(h) *Environmental Considerations*

The signal cables, solenoid valves, SRV operators and accumulators, and RV low-water level instrument lines are the only essential I&C equipment for the ADS located inside the drywell. These items will operate in the most severe environment resulting from a design basis LOCA (Section 3.11). Gamma and neutron radiation is also considered in the selection of these items. Equipment located outside the drywell (viz., the RPV level and DW pressure transmitters and ~~multiplex~~ data communication *interfaces) will also operate in their normal and accident environments.*

(i) *Operational Considerations*

A temperature element is installed on the SRV discharge piping several feet from the valve body. The temperature element provides input to ~~a multipoint recorder and interfaces with~~ *the* ~~PMCS computer~~ historian function *in the control room to provide a means of detecting SRV leakage during plant operation. When the temperature in any SRV discharge pipeline exceeds a preset valve, an alarm is sounded in the main control room. The alarm setting is enough above normal rated* *power drywell ambient temperatures to avoid spurious alarms, yet low enough to give early indication of SRV leakage.*

~~*Refer to Chapter 16 for setpoints and margin.*~~The Bases for Chapter 16 describe the methods for calculating setpoints and margins.

7.3.1.1.1.3 Reactor Core Isolation Cooling (RCIC) System—Instrumentation and Controls

STD DEP T1 2.4-3

STD DEP T1 3.4-1

STD DEP Admin

(3) Power Sources

The RCIC System is primarily *powered by the Division I 125 VDC system*. ~~*except,*~~ Exceptions include ~~*for the isolation valves for steam supply.*~~ the ~~*Inboard*~~ inboard *isolation valves* (including the steam line warm-up valve) which *are powered by 480 VAC Division I and* the *outboard* steam supply isolation valve is ~~*valves are*~~ *powered by 125 VDC Division II.* The logic power is as described in Section 7.1 for ELCS.

(4) Equipment

When actuated, the RCIC System pumps demineralized water from the condensate storage tank to the reactor vessel. The suppression pool provides an alternate source of water. The RCIC System includes a 100% capacity steam-driven turbine which drives a 100% capacity pump assembly, turbine and pump accessories, piping, valves, and instrumentation necessary to implement several flow paths. The arrangement of equipment and control devices is shown in Figure 5.4-8 (RCIC P&ID).

Level ~~*transducers*~~ transmitters *used for the initiation and* stopping RCIC ~~*tripping and pressure transducers for isolation of the RCIC System*~~ *are provided by the Nuclear Boiler System and are shared by other system channels within each division.* High drywell pressure signals are provided by the Nuclear Boiler System and are also shared by other system channels within each division. ~~*They*~~ These *are located* ~~*on instrument panels*~~ *outside the drywell but inside the* ~~*containment*~~ Reactor Building*. The only operating components of the RCIC System that are located inside the drywell are the inboard steamline isolation valve and the steamline warmup line isolation valve.*

The rest of the RCIC System normal I&C components are located in the Reactor Building. Cables connect the sensors ~~*(via the multiplexed optical data links described in Appendix 7A)*~~ (via the Essential Communication

Function) to control circuitry in the main control room. ~~Control system details are shown in Figure 7.3-3.~~

A design flow functional test of the RCIC System may be performed during normal plant operation by drawing suction from the suppression pool and discharging through a full flow test return line to the suppression pool. The discharge valve to the reactor vessel remains closed during the test and reactor operation remains undisturbed. All components of the RCIC System are capable of individual functional testing during normal plant operation. Control system decisions will provide automatic return from test to operating mode if RCIC System initiation is required. There are ~~three~~ two exceptions:

(i) ~~The flow controller in manual mode. This feature provides operator flexibility during system operation.~~ Not used

(ii) Steam inboard/outboard isolation valves are closed. Closure of either or both requires operator action to properly sequence their opening ~~(an alarm sounds when either of these valves leaves the fully open position)~~.

(iii) Breakers have been manually racked out of service. This condition is indicated in the main control room.

(a) Initiating Circuits

The RCIC System is initiated upon receipt of a high drywell pressure signal or a reactor vessel low water ~~level~~ Level 2 signal. High drywell pressure is monitored by four shared pressure transmitters (one from each division) in the Nuclear Boiler System. Reactor vessel low water level is monitored by four shared level ~~transducers~~ transmitters (one from each of the four electrical divisions) in the NBS that sense the pressure difference between a constant reference leg of water and the actual height of water in the vessel.

Each ~~transducer~~ transmitter supplies a signal ~~to a local multiplexer unit which performs signal conditioning and~~ for analog-to-digital conversion~~,~~ ~~(Appendix 7A)~~. The formatted, digitized sensor inputs are ~~multiplexed~~ transmitted with other sensor signals over an optical data link to the logic processing units in the main control room. All four transmitter signals are fed into the two-out-of-four logic for RCIC initiation.

The sensing lines for the ~~transducers~~ transmitters are physically separated from each other and tap off the reactor vessel at each of the four quadrants of the containment structure associated with the appropriate electrical divisions.

The RCIC System is initiated automatically after receipt of either of the two parameters just described and produces the design flow rate ~~within 30 seconds~~ in a time interval consistent with Table 6.3-1. The system *then functions to provide design makeup water flow to the reactor vessel until the amount of water delivered to the reactor vessel is adequate to restore vessel level. The RCIC turbine will shut down automatically upon receipt of high reactor water level* 8 *(two- out-of-four). The controls are arranged to allow manual startup, operation, and shutdown.*

The RCIC turbine is functionally controlled ~~as shown in Figure 7.3-3 (RCIC IBD)~~ by an internal turbine flow controller*. The turbine governor limits the turbine speed and adjusts the turbine steam ~~control valve~~* inlet *so that design pump discharge flow rate is obtained. The flow signal used for automatic control of the turbine is derived from a differential pressure measurement ~~across a flow element in the RCIC System pump discharge line~~* within the turbine. All flow controls are internal to the combined turbine pump*.*

The turbine is automatically shut down by tripping the turbine and closing the throttle valve if any of the following conditions are detected:

(i) Turbine overspeed

(ii) High turbine exhaust pressure

(iii) RCIC auto-isolation signal

(iv) Low pump suction pressure

(v) Reactor vessel high water level (Level 8)

(vi) Manual trip ~~actuated~~ activated *by the operator ~~(provided auto-initiating signal is not present)~~*

Turbine overspeed indicates a malfunction of the turbine control mechanism. High turbine exhaust pressure indicates ~~a~~ an *~~condition that threatens the physical integrity of~~* obstruction in *the exhaust line. Low pump suction pressure warns that cavitation and lack of cooling can cause damage to the pump which could place it out of service. ~~A turbine trip~~* RCIC shutdown *is initiated for these conditions so that if the causes of the abnormal conditions can be found and corrected, the system can be quickly restored to service. Turbine overspeed is* first *detected by ~~a standard turbine~~* an electrical overspeed sensor, and secondly by a throw-out pin *overspeed mechanical device. ~~Four pressure sensors are used to detect high~~* High *turbine exhaust pressure~~; any one sensor~~ can initiate turbine shutdown. ~~One~~* Two *pressure ~~sensor is~~* sensors can be *used to detect low RCIC System pump suction pressure* (only one of these need to function since the logic is structured such that one can be in calibration at any time).

RCIC is automatically isolated on detection o~~r~~f high steam flow or high temperature in the RCIC room. Either of these is an indication of a steam line leak or break.

High water level in the reactor vessel indicates that the RCIC System has performed satisfactorily in providing makeup water to the reactor vessel. ~~*Further*~~ A further *increase in level could result in* steam line ~~*RCIC System turbine*~~ *damage caused by gross carryover of moisture. The reactor vessel high water level* 8 *setting which* ~~*trips*~~ stops *the turbine is* below the bottom of the Main Steam Line (MSL) ~~*near the top of the steam separators*~~ *and is selected to prevent* ~~*gross moisture carryover to the turbine*~~ overflow into the MSLs*. Four shared level transmitters from the Nuclear Boiler System which sense differential pressure are arranged in two-out-of-four logic to initiate a turbine shutdown. However, should a subsequent low level signal recur, the RCIC System will automatically restart.* ~~*See Chapter 6 (activated devices) for discussion of auto isolation logic.*~~

(b) *Logic and Sequencing*

The scheme used for initiating the RCIC System is shown in Figure 7.3-3 (RCIC IBD). RCIC initially starts on the sensing of either a low water level signal or a high drywell pressure signal. This initiates a sequence of valve openings and a RCIC turbine ramp rate which results in rated flow to the reactor vessel in a time interval consistent with Table 6.3-1.

About 5 seconds after the initiation signal is received, the RCIC steam admission valve opens. The RCIC turbine controller controls the flow ramp rate to rated flow to the reactor vessel.

(c) *Bypasses and Interlocks*

To prevent the turbine/pump from being damaged by overheating at reduced RCIC pump discharge flow, a pump minimum flow bypass is provided to route the water discharged from the pump back to the suppression pool.

The minimum flow bypass is controlled by an automatic DC motor-operated valve. The control scheme is shown in Figure 7.3-3 (RCIC IBD). The valve is automatically closed at high flow or when either the steam admission *supply* valve *or turbine trip* ~~*valvs*~~ valves *are closed. Low flow, combined with high pump discharge pressure, opens the valve.*

To prevent the RCIC steam supply pipeline from filling up with water ~~*and cooling excessively*~~*, a condensate drain pot, steamline drain, and appropriate valves are provided in a drain pipeline arrangement just upstream of the turbine supply valve.* ~~*The controls position valves so that,*~~ ~~during~~ During *normal operation, steamline drainage is routed to* *the main condenser.The water level in the steamline drain condensate pot is controlled by a* steam trap. If above normal condenstation occurs, as is typical during initial steam line warm up a *level switch and a direct acting solenoid valve* ~~*which*~~ *energizes to allow condensate to flow out of the drain pot*, bypassing the normal steam trap. This condition is alarmed in the MCR. *Upon receipt of an RCIC initiation signal and subsequent opening of the steam* admission *supply* valve*,* ~~*the*~~ this *drainage path is shut off by redundant valves.*

To prevent the turbine exhaust line from filling with water, a condensate drain pot is provided to route the turbine exhaust line to a drain tank*.* ~~*The water in the turbine exhaust line condensate drain pot is routed to the clean radwaste system.*~~ *RCIC initiation and subsequent opening of the steam* admission *supply valve causes the* ~~*condensate*~~ exhaust *drainage line to be shut off by redundant valves.*

During ~~*test*~~Full Flow Test Mode *operation, the RCIC pump discharge is routed to the suppression pool. Two DC motor-operated valves are installed in the pump discharge to the suppression pool pipeline. The piping arrangement is shown in Figure 5.4-8 (RCIC P&ID). Upon receipt of an RCIC initiation signal* while in the Full Flow Test Mode*, the* RCIC pump discharge *valves* and CST suction valve *close* and the suction remains aligned to the suppression pool during this transition to the Vessel Makeup Mode. The RCIC pump suction may be remotely realigned to the CST, *as shown in Figure 7.3-3 (RCIC IBD).* ~~*The pump suction from the condensate storage pool is automatically closed or interlocked closed if the suppression pool suction valve is fully open.*~~ ~~Upon receipt of an RCIC initiation signal while in the Full Flow Test Mode, the RCIC pump discharge valves and CST suction valve close and the suction remains aligned to the suppression pool during this transition to the Vessel Makeup Mode. The RCIC pump suction may be remotely realigned to the CST, as shown in Figure 7.3-3 (RCIC IBD).~~ *Various indications pertinent to the operation and condition of the RCIC System are available to the main control room operator. Figure 7.3-3 (RCIC IBD) shows the various indications provided.*

(d) Redundancy and Diversity

On a network basis, the HPCF System is redundant and diverse to the RCIC System for the ECCS and safe shutdown function. Therefore, the RCIC System, as a system by itself, is not required to be redundant or diverse, although the instrument channels are redundant for operational availability purposes.

The RCIC System is actuated by high drywell pressure or by reactor low water level. Four NBS sensors monitor each parameter and combine in two sets of two-out-of-four logic signals in the ~~*safety system logic and control (SSLC)*~~ ESF Logic and Control System (ELCS)*. A permissive* *signal from either set initiates the RCIC System. The sensor outputs themselves are shared by other systems in common with each division ~~(see NBS P&ID Figure 5.1-3)~~.*

(e) Actuated Devices

All automatic valves in the RCIC System are equipped with remote manual test capability so that the entire system can be operated from the control room. Motor-operated valves are equipped with limit and torque switches. Limit switches turn off the motors when movement is complete. In the closing direction, torque switches turn the motor off when the valve has properly seated. Thermal overload devices are used to trip motor-operated valves during testing only. (for more information on valve testing, see Subsection 3.9.3.2) All motor-operated and air- operated valves provide control room indication of valve position. ~~The system~~ RCIC *is capable of initiation independent of AC power.*

To assure that the RCIC System can be brought to design flow rate ~~within 30 seconds~~ in an time interval consistent with Table 6.3-1 *from receipt of the initiation signal, the following maximum operating times for essential RCIC valves are provided by the valve operation mechanisms:*

— *RCIC turbine steam* admission *supply valve: 15 s*

— *RCIC pump discharge valves: 15 s*

— *RCIC pump minimum flow bypass valve: ~~15~~*5 *s*

The operating time is the time required for the valve to travel from the fully-closed to the fully-open position or vice versa. A normally closed steam admission *supply valve is located in the turbine steam supply pipeline just upstream of the turbine stop valve. The control scheme for this valve is shown in Figure 7.3-3 (RCIC IBD). Upon receipt of an RCIC initiation signal this valve opens and remains open until closed by a high water level signal, or by operator action from the main control room.*

Two normally open isolation valves, one inboard and one outboard, are provided in the steam supply line to the turbine. ~~The~~ These *valves automatically close upon receipt of an RCIC isolation signal. The inboard isolation valve has a bypass line with an automatic remotely controlled valve in it. The bypass line is used to equalize and preheat the steamline* to the RCIC steam admission supply valve*.*

The ~~instrumentation~~ signals *for isolation* are provided by the Leak Detection and Isolation System (~~LDI~~LDS) and *consists of the following:*

— ***Outboard RCIC turbine isolation valve:***

(i) *Ambient temperature sensors—RCIC equipment area ~~B~~ high temperature.*

(ii) *~~Main steamline pipe tunnel ambient temperature A or B high.~~* Not used*.*

(iii) *RCIC flow instrument line B break or high flow.*

(iv) *Two pressure transmitters and trip logic—RCIC turbine exhaust ~~diaphragm (B and F)~~ high pressure. Both trip logic channels must activate to isolate.* ~~Two pressure transmitters and trip logic—RCIC turbine exhaust high pressure. Both trip logic channels must activate to isolate.~~

(v) *Pressure transmitter and trip logic RCIC steam supply pressure low.* ~~Not used~~

(vi) *RCIC manual isolation Channel B.*

— ***Inboard RCIC turbine isolation valve:***

~~Except for the suffix notations of A and E replacing B and F, a similar set of instrumentation causes the inboard valve to isolate.~~ The same set of two-out-of four logic causes the inboard valve to isolate, except manual isolation is a separate control in Division I.

Two pump suction valves are provided in the RCIC System. One valve lines up pump suction from the condensate storage ~~pool~~ tank*, the other one from the suppression pool. The condensate storage ~~pool~~* tank *is the preferred source. The control arrangement is shown in Figure 7.3-3 (RCIC IBD). Upon receipt of an RCIC initiation signal, the normally open condensate storage ~~pool~~* tank *suction valve automatically opens if closed. Condensate storage ~~pool~~* tank *low water level or suppression pool high water level automatically opens the suppression pool suction valve. Full opening of this valve automatically closes the condensate storage ~~pool~~* tank *suction valve.*

One RCIC pump discharge valve and ~~one~~ two *check ~~valve~~* valves *are provided in the pump discharge pipeline. The control scheme for the discharge valve is shown in Figure 7.3-3 (RCIC IBD). This* discharge *valve is arranged to open upon receipt of the RCIC initiation signal and closes automatically upon closure of the turbine ~~trip and throttle~~* stop *valve or* the RCIC *steam* admission *supply valve.*

~~The auxiliary systems that support the RCIC System are the non-safety- related Gland Subsystem (which prevents turbine steam leakage) and the Lube Oil Cooling Water Subsystem. An RCIC initiation~~

signal activates the vacuum pump of the barometric condenser and opens the cooling water supply valve, thereby initiating the gland seal and lube oil cooling functions. These systems remain on until manually turned off. However, the cooling water supply valve will close automatically on receiving a two-out-of-four high reactor water level signal.

(g) *Testability*

Verification of sensor signals is accomplished by cross comparison between the redundant channels. Each sensor signal *is monitored on the* ~~*SSLC*~~ ELCS ~~*displays.*~~ and Main Control Room (MCR) *displays. Additional testing of the initiation sensors which are located outside the drywell may be accomplished by valving out each sensor and applying a test pressure source. This verifies the calibration range in addition to the operability of the sensor. The logic is* manually verified in accordance with Technical Specification Requirements~~.~~ ~~*tested every 10 minutes by automatic self-test circuits.*~~ ~~*The automatic self-test system (the sixth test)*~~ SSLC testing as *discussed in Subsection 7.1.2.1.6 is also applicable here for the RCIC System.* ~~*With a division of sensors bypass in place, calibrated, variable ramp signals are injected in place of the sensor signals and monitored at the SSLC control room panels for linearity, accuracy, fault response, and downscale and upscale trip response.*~~

(5) ~~*Environmental Considerations*~~

~~*The only RCIC control components located inside the drywell that must remain functional in the environment resulting from a loss-of-coolant accident are the control mechanisms for the inboard isolation valve and the steamline warmup line isolation valve. The RCIC I&C equipment located outside the drywell is selected in consideration of the environments in which it must operate. All safety-related RCIC instrumentation is seismically qualified to remain functional following a safe shutdown earthquake (SSE) (Section 3.10).*~~

(6) *Operational Considerations*

Normal core cooling is required in the event that the reactor becomes isolated from the main condenser during normal operation by a closure of the main steamline isolation valves. Cooling is necessary due to the core fission product decay heat. Steam pressure is relieved through the SRVs to the suppression pool. Under these conditions, ~~*The*~~ *RCIC* ~~*System*~~ *maintains reactor water level by providing the makeup water. Initiation and control are automatic.*

The following indications are available in the main control room for operator information:

Indication

RCIC steamline supply pressure

RCIC valve (test bypass to suppression pool) position

RCIC pump discharge pressure

RCIC pump discharge flow

~~*RCIC pump discharge minimum flow*~~

RCIC turbine speed

RCIC turbine exhaust line pressure

~~*RCIC turbine exhaust diaphragm pressure*~~

~~Position of motor-operated valves~~

~~Position of solenoid-operated valve~~

~~Turbine Trip~~

~~System status (power, test, isolation)~~

~~Annunciators~~

~~***Indicating Lamps***~~

Position of ~~all~~ motor-operated valves

Position of ~~all~~ solenoid-operated valves

Turbine trip

~~*Significant sealed-in circuits*~~

~~*Pump status*~~

System status (power, test, isolation)

~~***Annunciators***~~

Annunciators ~~are provided as shown in the RCIC system IBD (Figure 7.3-3) and the RCIC System P&ID (Figure 5.4-8).~~

(7) Setpoints

The reactor vessel low water Level 2 setting for RCIC System initiation is selected high enough above the active fuel to start the RCIC System in time to prevent the need for the use of the low pressure ECCS. The water level *setting is far enough below normal levels that spurious RCIC System startups are avoided ~~(see Chapter 16 for actual setpoints and margin)~~.*

7.3.1.1.1.4 RHR/Low Pressure Flooder (LPFL) Instrumentation and Controls

STD DEP T1 3.4-1

STD DEP 7.3-1

STD DEP 7.3-5

STD DEP 7.3-9

STD DEP 7.3-10

STD DEP Admin

(3) Equipment Design

Motive power for the RHR System pumps is supplied from AC buses that can receive standby AC power. The three pumps are powered from Division I, II, and III ESF buses, which also provide power to the RCIC (Division I) and HPCF (Divisions II and III) Systems. Motive power for the automatic valves comes from the bus that powers the pumps for that division, except for the special case involving isolation valves. Control power for the LPFL Subsystem components comes from the divisional Class 1E AC buses. Logic power is from the ~~SSLC~~ ELCS *power supply for the division involved. Trip channels for the LPFL Subsystem are*:

(a) Initiating Circuits

The LPFL Subsystem is initiated automatically on receipt of a high drywell pressure or low reactor water level signal (Level 1), and a low reactor pressure permissive to open the injection valve. The LPFL may also be initiated manually.

Reactor vessel ~~low~~ water ~~level (~~Level 1~~)~~ is monitored by ~~eight~~ four *level transmitters from the Nuclear Boiler System (NBS) which are mounted on instrument racks in the drywell. These transmitters sense the difference between the pressure due to a constant reference leg of water and the pressure due to the actual height of water in the vessel. The ~~multi-~~* four *~~division~~* divisions of *transmitters are shared with other systems within the respective divisions. ~~Four transmitters provide signals (one from each division) to RHR Divisions I and III. The other four transmitters provide similar signals to RHR Division II.~~*

Drywell pressure is monitored by four pressure transmitters from the NBS which are mounted on instrument racks in the containment. These transmitters are also shared with other system channels within the respective divisions. The sensors provide inputs to local ~~multiplexer~~

~~units~~ RDLCs which perform signal conditioning and analog-to-digital conversion ~~(Appendix 7A)~~. The formatted, digitized sensor inputs are ~~multiplexed~~ transmitted with other sensor signals over an optical data link to the logic processing units in the main control room. The four signals from each parameter are combined, through appropriate optical isolators, in two-out-of-four logic for each division of the RHR/LPFL System. This assures that no single failure event can prevent initiation of the RHR/LPFL Systems. The initiation logic for the RHR System (including LPFL) is shown in Figure 7.3-4.

The LOCA signals (high drywell pressure and Level 1 water level) which trigger the initiation logic also initiate starting of the respective division diesel generator.

The LPFL injection valve actuation logic requires a reactor low pressure permissive signal for automatic actuation on reactor ~~low~~ water ~~(~~Level 1~~)~~ or high drywell pressure. The reactor pressure logic is a two-out-of-four network of shared sensor channels from the NBS and is similar in arrangement to the initiation logic just described.

Manual opening of the injection valve also requires the two-out-of-four reactor low pressure permissive.

(b) Logic and Sequencing

The transmitters which provide the initiation signals are from the NBS and are shared by other I&C system channels in common with each of the four divisions. This facilitates full two-out-of-four initiation logic for all LOCA parameters while utilizing efficient instrumentation. Optical isolators are used to provide proper separation of the electrical divisions. The four drywell pressure sensors supply isolated signals to the separate two-out-of-four logic of all three divisions of the RHR System. ~~Similarly, four water level sensors supply signals to RHR Divisions I and III. However, four different sensors supply the water level signals to RHR Division II.~~ After an initiation signal is received by the LPFL control circuitry, the signal is sealed-in until manually reset. The logic is shown in Figure 7.3-4.

(d) (LPFL) Redundancy and Diversity

The LPFL Subsystem is actuated by reactor vessel ~~low~~ water ~~level (~~Level 1~~)~~ and/or drywell high pressure. Either or both of these diverse conditions may result from a design basis LOCA and lesser LOCAs.

(e) (LPFL) Actuated Devices

The functional control arrangement for the RHR/LPFL System pumps is shown in Figure 7.3-4. All three pumps start after a ~~10 second~~ time delay, consistent with Table 6.3-1, *provided normal or emergency* *power is available from their divisional sources. However, the diesel load sequence circuitry controls the demand placed on the onsite standby sources of power (Section 8.3). The delay times for the pumps to start when normal AC power is not available include approximately 3 seconds for the start signal to develop after the actual reactor vessel ~~low~~ water level* 1 *or drywell high pressure occurs, ~~10 seconds~~* a time delay consistent with Table 6.3-1 ~~in~~ *for the standby power to become available, and a sequencing delay to reduce demand on standby power. The LPFL Subsystem is designed to provide flow into the reactor vessel within ~~36 seconds~~* the time allowed by Table 6.3-1 *of the receipt of the accident signals and the low reactor pressure permissive.*

The RHR System pump suction ~~valves~~ valve *from the suppression pool ~~are~~* is *normally open.* Shutdown cooling isolation valves must be closed to permit suction from the Suppression Pool. *To reposition the valves, a keylock switch must be turned in the control room. On receipt of an LPFL initiation signal~~, the reactor Shutdown Cooling System (SCS) valves and~~ the RHR test line valves are signaled to close (although they are normally closed) to ensure that the RHR System pump discharge is correctly routed. ~~Included in this set of valves are the valves that, if not closed, would permit the main system pumps to take suction from the reactor vessel itself (a lineup used during normal SCS operation).~~*

(g) Testability

The LPFL I&C equipment is capable of being tested during normal operation. Cross-channel comparison verifies analog transmitter outputs. Drywell pressure and low water level initiation transmitters can be individually valved out of service and subjected to a test pressure. This verifies the calibration range in addition to the operability of the transmitters. The instrument ~~channel trip~~ setpoint is verified by viewing the displays for each instrument~~.~~ *~~automatic self-test functions in the SSLC which simulate programmed trip setpoints and monitor the response~~. The logic is also ~~automatically~~ tested ~~by the self-test system~~* as *described in Subsection 7.1.2.1.6. Other control equipment is functionally tested during normal testing of each loop. Indications in the form of panel lamps and annunciators are provided in the control room.*

(i) Operational Considerations

The pumps, valves, piping, etc., used for the LPFL are used for other operating modes of the RHR System. Initiation of the LPFL mode is automatic and no operator action is required for at least 30 minutes. ~~The operator may control the RHR pumps and injection valves manually after LPFL initiation to use RHR capabilities in other modes if the core is being cooled by other emergency core cooling systems.~~ Other RHR modes are activated by Mode switches in the MCR. For example to enter the Containment Spray mode, this switch is first “Armed” and then the "Initiate" Push button is pressed. This action must occur within a limited interval. This assures that this is an intentional action by the operator. Also to transfer to these and other RHR Modes, mode specific permissives must be met. This reduces or eliminates the possibility of operator error.

7.3.1.1.2 Leak Detection and Isolation System (LDS)—Instrumentation and Controls

STD DEP T1 2.3-1

STD DEP T1 2.4-2

STD DEP T1 2.4-3

STD DEP T1 3.4-1

STD DEP 7.3-11

STD DEP 7.3-12

(2) Supporting System (Power Sources)

All LDS logic power is supplied by the respective divisional ~~SSLC~~ ELCS *logic power supplies. See Section 8.3 for a description of the ~~SSLC~~* ELCS *logic power supplies.*

The power for the MSIVs pilot solenoid valve control logic is supplied from all four divisions of the ~~SSLC~~ RTIS *buses. The MSIVs are spring-loaded, piston-operated pneumatic valves designed to fail closed on loss of electric power or pressure to the valve operator.*

(3) Input Variables and Sensing Methods

(a) RPV Low Water Level

Reactor vessel low water level signals are generated by differential pressure transmitters connected to taps located above and below the water level in the reactor vessel. The transmitters sense the difference between pressure caused by a constant reference leg of water and the pressure caused by the actual water level in the vessel. The ~~SSLC~~ ELCS *monitors for low water level and provides trip signals in all four divisions at four different low reactor water levels. The signals are shared systems within the same division (i.e., RPS, ECCS) and are defined as follows:*

(b) ~~Main Steamline Radiation~~ Not Used

~~Main steamline (MSL) radiation is monitored by gamma sensitive radiation monitors in the Process Radiation Monitoring System (Section~~

~~*7.6). The objective of the MSL Radiation Monitoring Subsystem is to monitor for the gross release of fission products from the fuel and, upon indication of such release, initiate appropriate action to limit fuel damage and further release of fission products.*~~

~~*The process radiation monitor detectors are physically located near the main steamlines just downstream of the outboard MSIVs. The detectors are geometrically arranged to detect significant increases in radiation level with any number of main steamlines in operation.*~~

~~*When a significant increase in the main steamline radiation level is detected, trip signals are transmitted to the Reactor Protection System (RPS) to indicate reactor trip and to the LDS to initiate closure of all MSIVs and the steamline drain valves.*~~

(l) ~~*Valve Leakage Monitoring*~~ Not Used

~~*Large remote power-operated valves located in the drywell for the NBS, CUW, RCIC, and RHR Systems are fitted with drain lines from the valve stems. Each drain line is located between two sets of valve stem packing. Leakage through the inner packing is carried to the drywell equipment drain sump. Leakage during hydrotesting may be observed in drain line sight glasses installed in the drain line to the sump. A remote-operated solenoid valve on each line is provided to isolate a leaking line, and may be used during plant operation, in conjunction with the sump instrumentation, to identify the specific process leaking valve.*~~

(m) Drywell and Secondary Containment Sump Monitoring

Each sump monitoring system is equipped with two pumps and control instrumentation. The two drywell drain sumps are each equipped with a sonic level element and a level transmitter for monitoring level changes in the sump. The instrumentation provides indication and alarm of excessive fill rate or pumpout frequency of the sumps. The rate at which the drain sump fills with reference to the frequency of sump pump operation determines the leakage rate. The drain sump instrumentation has a sensitivity of detecting reactor coolant leakage of 3.785 L/min within a 60-minute period. Alarm setpoints (nominal values) *established at ~~95~~* 114 *L/min for* floor and *equipment drain sumps ~~and~~* (total leakage) *to 19 L/min for floor drain sumps* and 8 L/min for increase floor drain sump flow within the previous 4 hours*. The drywell floor drain sump collects unidentified leakage from such sources as floor drains, valve flanges, closed cooling water for reactor services and condensate from the drywell atmosphere coolers. The drywell equipment drain sump collects identified leakage from known sources.*

(q) ~~*RCIC Steamline Pressure Monitors*~~

~~*Pressure in the RCIC steamline is monitored to provide RCIC turbine shutoff and closure of the RCIC isolation valves on low steamline pressure as a protection for the turbine. This line pressure is monitored by pressure transmitters connected to one tap of the elbows used for flow measurement upstream of the steamline isolation valves (see Paragraph j). Four divisional channels of monitoring are provided for RCIC isolation. Division 1 isolation signal isolates the inboard valves, while Division 2 isolation signal isolates the outboard valves.*~~

(r) RCIC Turbine Exhaust Line ~~Diaphragm~~ Pressure Monitors

Pressure ~~between the rupture disc diaphragms~~ in the RCIC System turbine exhaust vent line is monitored by four channels of pressure instrumentation (two in Division I and two in Division II). Both logic channels of Division I trip on high turbine exhaust pressure to close the inboard RCIC isolation valves and trip the turbine. Both logic channels of Division II trip to close the outboard RCIC isolation valve and trip the turbine. The instrumentation channel equipment and piping are provided by the RCIC System as an interface to the LDS.

(w) Feedwater Line Differential Pressure

The LDS monitors the differential pressure to detect a break in the piping. If a confirmatory high drywell pressure signal is also present then a trip of the condensate pumps is initiated.

(7) Redundancy and Diversity

(a) Main Steamline

Redundancy is provided by the instrumentation to monitor each essential variable as follows:

(iii) ~~Four divisional radiation instrument channels monitor for high MSL radiation in the MSL tunnel area.~~ Not Used

(d) Reactor Core Isolation Cooling (RCIC)

(ii) Four RCIC turbine exhaust ~~diaphragm~~ pressure monitoring channels (two in each of two divisions).

7.3.1.1.3 RHR/Wetwell and Drywell Spray Cooling Mode—Instrumentation and Controls

STD DEP T1 3.4-1

STD DEP 7.1-1

STD DEP 7.3-13

STD DEP Admin

(3) Equipment Design

(a) Initiating Circuits

***Drywell Spray B**: Drywell pressure is monitored by four shared pressure transmitters mounted in instrument racks in the containment.*

Signals from these transmitters are routed to the local ~~multiplexer units~~ RDLCs *which convert analog to digital signals and send them through fiber optic links for logic processing in the control room. Any two-out-of-four signals provide the permissive to* manually *initiate the ~~WDSC.~~* Drywell Spray Mode.

Initiation logic for drywell spray B is identical to drywell spray C.

***Wetwell Spray B:** The initiation of wetwell spray* mode *is manual and ~~does not have an interlock.~~* can be initiated provided RPV Water Level is above Level 1. *The operator bases judgment on the instrumentation indication of the condition of the wetwell air space temperature.*

Operation of wetwell spray B is identical to wetwell spray C.

(b) Logic Sequencing

Wetwell and or Drywell Spray Modes can be entered separately or by initiating the Containment Spray Mode (which activates both). Most commonly this occurs after ~~LPCF~~LPFL initiation

The operating sequence of wetwell and drywell spray ~~following receipt of the~~ after *LPFL ~~initiating signals~~* initiation *is as follows:*

(i) The RHR pumps ~~are~~ continue *operating.*

(ii) Valves in other RHR modes are automatically repositioned to ~~LPFL injection.~~ ~~to~~ the Wetwell / Drywell Spray Modes.

(iii) The service water ~~emergency~~ pumps ~~are signaled to start.~~ continue running.

(iv) *Service water supply and discharge valves to the RHR heat exchanger ~~are~~ ~~signaled to~~* remain *open.*

(v) *The heat exchanger outlet valve opens and the heat exchanger bypass valve is signaled to close.*

(vi) *Vessel injection ~~takes place to flood the reactor~~* is terminated when the RHR Containment Spray Mode is selected. Alternately the Drywell or Wetwell spray modes can be initiated independently.

(vii) *In the presence of high drywell pressure ~~and/or high wetwell pressure, the injection valve is manually closed after the initial injection.~~* , the Drywell spray valves will automatically open*.*

(viii) *~~Drywell spray and~~* The *wetwell spray ~~valves are manually opened~~* valve will open *to perform the spray function* without any permissives*.*

The spray system will continue to operate until manually terminated by the operator or ~~when a RHR initiation signal closes the wetwell spray valve or an injection valve not fully closed signal closes the drywell spray valves. The spray system~~ will automatically terminate and realign to the LPFL *injection mode~~,~~* on receipt of a RPV Water Level 1, *since core cooling has priority.*

(c) *Bypass and Interlocks*

No bypasses are provided for the wetwell and drywell spray system.

~~No interlock is provided for~~ The *wetwell spray function* is interlocked with reactor vessel water Level 1 as described in 7.3.1.1.3(a)*.*

(g) *Testability*

The Wetwell and Drywell Spray System is capable of being tested up to the last discharge valve during normal operation. Drywell and wetwell pressure channels are tested by cross-comparison between related channels. Any disagreement between the display readings for the channels would indicate a failure. The instrument ~~channel trip~~ setpoint is verified by viewing the displays for each instrument~~.~~ *~~automatic self-test functions in the SSLC which simulate programmed trip setpoints and monitor the response~~. Testing for functional operability of the control logics is accomplished by the automatic self-test system (Subsection 7.1.2.1.6). Other control equipment is functionally tested during manual testing of each loop. Indications in the form of panel lamps and annunciators are provided in the control room.*

(i) *Operational Considerations*

~~See Chapter 16 for setpoints and margin.~~The Bases for Chapter 16 describe the methods for calculating setpoints and margins.

7.3.1.1.4 RHR/Suppression Pool Cooling Mode—Instrumentation and Control

STD DEP 7.3-14

(3) Equipment Design

(b) Logic and Sequencing

The operating sequence of suppression pool cooling, following indication that SP temperature is HIGH, is as follows:

(i) The RHR System pumps are started or continue to operate.

(ii) Valves in other RHR modes are ~~manually~~ automatically repositioned to align to SPC mode.

(iii) RHR service water discharge valves to the RHR heat exchanger are opened.

(iv) If performed following LPFL initiation, the Suppression Pool Cooling Modes switch is first “Armed” and the “Initiate” Pushbutton is pushed. At that time the *injection valves are manually closed and SP valves are opened.*

(v) The SPC mode will continue to operate until the operator ~~closes the SPC discharge valves~~ activates another permitted mode~~,~~ *or when reactor low water level reoccurs, in which case the injection valve will auto-open and the SP discharge valve will auto-close.*

(vi) Automatic initiation of the SPC mode can only happen when initiated from the RHR Standby Mode. The operator must terminate this mode manually.

7.3.1.1.7 Reactor Building Cooling Water System and Reactor Service Water System — Instrumentation and Controls

STD DEP 7.1-1

STD DEP 7.3-15

(3) Equipment Design

(i) Safety Interfaces

The safety interfaces for the RCW System Division I, II, and III controls are as follows:

— *Division I, ~~and~~ II,~~II,~~ and III RCW flow signals to the MCR and Divisions I and II RCW flow signal to the RSS.*

— ~~*RCW Hx*~~ RSW *A or D strainer differential pressure MCR annunciator.*

(j) Operational Considerations

Process operating parameters and equipment status information are provided in the control room for the operator to accurately assess system performance. Alarms are also provided to indicate malfunction in the system. Refer to IBD Figure 7.3-7 for specific indication of equipment status in the control room. ~~*See Chapter 16 for setpoints and margin.*~~The Bases for Chapter 16 describe the methods for calculating setpoints and margins.

7.3.1.1.10 High Pressure Nitrogen Gas Supply System—Instrumentation and Controls

STD DEP Admin

(3) Equipment Design

(d) Redundancy and Diversity

The HPIN storage bottles are in two racks separated from each other. Additionally, in each rack there are two banks of ~~*two*~~ five *bottles each. One bank is in service and the second is in standby.*

7.3.1.1.11 ~~*Flammability Control System—Instrumentation and Controls*~~Not Used

STD DEP T1 2.14-1

~~*(See Subsection 6.2.5)*~~

7.3.1.2 Design Basis Information

STD DEP 1.8-1

STD DEP 7.1-1

STD DEP Admin

IEEE~~-~~ ~~279~~ 603 *defines the requirements for* ~~*design bases*~~ safety systems designations and the safety systems criteria (Sections 4 and 5). ~~*Using the IEE 279 format, the*~~ The *following nine paragraphs fulfill this requirement for systems and equipment described in this seciton.*

(3) Number of Sensors and Location

There are no sensors in the LDS or ECCS, which have a spatial dependence, and, therefore, location information is not relevant. The only sensors used to detect essential variables of significant spatial dependence are the neutron flux detectors [Subsection 7.2.2.1(6)], the Suppression Pool Temperature Monitors [Subsection 7.6.1.7], *and the radiation detectors of the Process Radiation Monitoring System. These are in Section 7.6. All other systems discussed in Section 7.3 have sensors which have no spatial dependence.*

(5) Margin Between Operational Limits

The methods for calculating the *margin between operational limits and the limiting conditions of operation for the ESF System instruments are* ~~*listed in*~~ described in the Bases for *Chapter 16. The margin includes the consideration of sensor and instrument channel accuracy, response times, and setpoint drift.*

7.3.2 Analysis

7.3.2.1 Emergency Core Cooling Systems—Instrumentation and Controls

7.3.2.1.1 General Functional Requirements Conformance

STD DEP 7.3-4

Initiation of the Automatic Depressurization Subsystem (ADS) occurs when reactor vessel low water level and drywell high pressure are sensed, or when the ~~*8 minute*~~ *drywell high pressure bypass timer* initiated by RPV Level 1 water level *runs out. Therefore it is not required that the nuclear system breach be inside the containment. This control arrangement is satisfactory in view of the automatic isolation of the reactor vessel for breaches outside the drywell and because the ADS is required only if the HPCF and/or RCIC System fail to maintain adequate reactor water level.*

The control arrangement used for the ADS is designed to avoid spurious actuation (Figure 7.3-2). The ADS relief valves are controlled by two trip systems per division, both of which must be in the tripped state to initiate depressurization. Within each trip system, both drywell pressure high trip or time out of the ~~*8 minute*~~ *drywell high pressure bypass timer and* ~~*low*~~ Level 1 *reactor water level trip are required to initiate a trip system.*

7.3.2.1.2 Specific Regulatory Requirements Conformance

STD DEP T1 3.4-1

STP DEP 1.1-2

STD DEP 1.8-1

STD DEP 7.3-1

STD DEP 7.3-5

STD DEP 7.3-7

STD DEP 7.3-16

STD DEP 7.3-17

~~Table 7.1-2 identifies the ECCS and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.~~

(1) *10CFR50.55a (IEEE-~~279~~603)*

The ECCS incorporates two divisions of HPCF, one division of stream-driven RCIC, two divisions of ADS and three divisions (three loops) of LPFL (RHR/low pressure flooders). This automatically actuated network of Class 1E redundant high pressure and low pressure systems assures full compliance with IEEE-~~279~~ 603.

All components used for the ECCS are qualified for the environments in which they are located (Sections 3.10 and 3.11). All systems which make up the ECCS network are actuated by two-out-of-four logic combinations of sensors which monitor drywell pressure and reactor water level. There are a total of eight wide range *water level sensors and four drywell pressure sensors which are supplied by the Nuclear Boiler System. These instruments are shared by the ECCS as well as the RPS and other systems which require actuation signals from these essential variables. However, each system receives all four signals as input to its own unique voting logic incorporated in the ~~safety system logic and control (SSLC)~~* ESF Logic and Control System (ELCS) *network. If individual channels are bypassed for service or testing, the voting logic reverts to two-out-of-three.*

Each of these electrical divisions contains one of the drywell pressure sensors and two of the reactor water level sensors which contribute to the two-out-of- four voting logic. All of these signals are ~~multiplexed and passed~~ transmitted *through fiber-optic medium before entering the voting logic of the redundant divisions involved in the systems which make up the ECCS network.*

(3) *Regulatory Guides (RGs)*

~~In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, the following RGs are addressed for the ECCS:~~

(a) *RG 1.22—"Periodic Testing of Protection System Actuation Functions"*

~~System logic and component testing capabilities are provided to enable fullflow testing during reactor operation as described in Subsection~~

~~7.3.1.1.1. The ECCS fully complies with this regulatory guide using the following two clarifying interpretations:~~

(i) Periodic testing is interpreted to mean testing of actuation devices ~~(which use pulse testing)~~ but not to include testing of the actuated equipment which is tested during surveillance testing.

(ii) ~~Each bypass condition shall be automatically annunciated on a trip system basis (i.e., each channel does not require separate annunciation).~~

(c) RG 1.53—"Application of the Single-Failure Criterion to Nuclear Power Protection Systems"

The ECCS generally meets the requirements of RG 1.53 in addition to Section ~~4.2~~ 5.1*of IEEE~~-279~~* 603 *and IEEE-379. However, specific exception is taken with regard to Paragraph C-2 as follows: Specific items which cannot be energized for test during plant operation, or tested by other than continuity tests without degrading plant operability or safety, will be exempt from the requirements of this paragraph. ~~(e.g., the SRV solenoid pilot valves)~~*

~~Redundant sensors and logic are utilized as described in Paragraph (1) above. There are no mode switches associated with the ECCS.~~

(e) RG 1.75-"Physical Independence of Electric Systems"

The ECCS is in compliance with this regulatory guide assuming clarifications and alternates described in Subsection 7.1.2.10.5. Separation within the ECCS is such that controls, instrumentation, equipment, and wiring is segregated into four separate divisions designated I, II, III, and IV. Sensor input signals are in Division I, II, III, and IV. Control logic is performed in Divisions I, II and III. *Control and motive power separation is maintained in the same manner. Separation is provided to maintain the independence of the four divisions of the circuits and equipment so that the protection functions required during and following any design basis event can be accomplished.*

(4) Branch Technical Positions (BTP)

(c) BTP ICSB 21—"Guidance for Application of Regulatory Guide 1.47"

~~The ABWR design is a single unit.~~ ECCS is not shared between units. *Therefore, item B-2 of the BTP is not applicable. Otherwise, the ECCS is in full compliance with this BTP.*

(d) BTP IGSB 22—"Guidance for Application of Regulatory Guide 1.22"

In general, actuated equipment within the reactor protection system can be fully tested during reactor operation. Exceptions for the RPS scram function are discussed in Subsection 7.2.2.2.3.1 (10). Exceptions for ECCS include ~~*the ADS valve pilot solenoids and the*~~ *LPFL shutdown valves which cannot be opened while the reactor is pressurized. However,* ~~*both*~~ these *can be tested during reactor shutdown.* ~~*In addition, the ADS valve solenoids are monitored for continuity during the logic self- test.*~~

7.3.2.2 Leak Detection and Isolation System—Instrumentation and Controls

7.3.2.2.2 Specific Regulatory Requirements Conformance

STD DEP T1 3.4-1

STP DEP 1.1-2

STD DEP 1.8-1

~~*Table 7.1-2 identifies the LDS and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

*(1) 10CFR50.55a (IEEE-~~279~~*603*)*

All components used for the safety isolation functions are qualified for the environments in which they are located (Sections 3.10 and 3.11). Most initiation parameters are represented by all four divisions which actuate the isolation functions via two-out-of-four logic permissives. Most of the sensors are provided by the Nuclear Boiler System. These instruments are shared by the ECCS, as well as the RPS and other systems which require actuation signals from these essential variables. However, each system receives all four signals as input to its own unique voting logic incorporated in the ~~*safety system logic and control (SSLC)*~~ ESF Logic and Control System (ELCS) *network. If individual channels are bypassed for service or testing, the voting logic reverts to two-out-of-three.*

All of these signals are ~~*multiplexed and*~~ *passed through fiber optic medium before entering the voting logic of the redundant divisions involved in the isolation valve logic. Separation and isolation are thus preserved both mechanically and electrically in accordance with IEEE-~~279~~*603 *and Regulatory Guide 1.75. For further information see Subsection 9A.5.5.7.*

*Other requirements of IEEE-~~279~~*603 *such as testing, bypasses, manual initiation logic seal-in, etc., are described in Subsection 7.3.1.1.2.*

(4) Branch Technical Positions (BTPs)

~~*In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the LDS. They are addressed as follows:*~~

(a) BTP ICSB 21—"Guidance for Application of Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ ~~LDI~~LDS is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the LDS is in full compliance with this BTP.*

7.3.2.3 RHR/Wetwell and Drywell Spray Mode—Instrumentation and Controls

7.3.2.3.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

STD DEP 7.3-13

~~*Table 7.1-2 identifies the WDSC mode of the RHR System and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

*(1) 10CFR50.55a (IEEE ~~279~~*603*)*

All components used for the safety functions are qualified for the environments in which they are located (Sections 3.10 and 3.11). ~~*This*~~ The Drywell Spray *mode of the RHR System (unlike the LPFL mode which is automatically actuated by LOCA)* ~~*is automatically*~~ can be manually *actuated should high pressure conditions occur in the drywell* ~~*and wetwell air space*~~*.* The Wetwell Spray mode can be initiated at any time provided the proper permissives are present.

*The suppression cooling mode pool is designed in accordance with all requirements of IEEE ~~279~~*603 *as described in Subsection 7.3.1.1.3.*

~~*A clarification should be made with regard to IEEE-279, Section 4.19.*~~ *The parent RHR System annunciates activity at the loop level (i.e., "RHR LOOP A, B, C ACTIVATED"). However, the individual mode of the RHR System is not separately annunciated.*

(4) Branch Technical Positions (BTPs)

In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the ~~*WDSC*~~ Wetwell / Drywell Spray *mode. They are addressed as follows:*

(a) BTP ICSB 21— "Guidance for Application of Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ RHR equipment is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the WDSC is in full compliance with this BTP.*

7.3.2.4 RHR/Suppression Pool Cooling Mode—Instrumentation and Controls

7.3.2.4.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

(1) 10CFR50.55a (IEEE ~~279~~603)

The suppression cooling mode pool system is designed in accordance with all requirements of IEEE ~~279~~603 as described in Subsection 7.3.1.1.4.

~~*A clarification should be made with regard to IEEE 279, Section 4.19.*~~ *The parent RHR System annunciates activity at the loop level (i.e., "RHR LOOP A, B, C ACTIVATED"). However, the individual mode of the RHR System is not separately annunciated.*

~~*Table 7.1-2 identifies the SPC mode of the RHR System and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

(4) Branch Technical Positions (BTPs)

~~In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the SPC mode. They are addressed as follows:~~

(a) BTP ICSB 21— "Guidance for Application of Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ RHR equipment is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the SPC mode is in full compliance with this BTP.*

7.3.2.5 Standby Gas Treatment System—Instrumentation and Controls

7.3.2.5.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

~~*Table 7.1-2 identifies the SGTS and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

(1) 10CFR50.55a (IEEE-~~279~~603)

The SGTS is designed to meet all the requirements of IEEE-~~279~~603. Detailed system design descriptions are given in Subsection 7.3.1.1.5.

(4) Branch Technical Positions (BTPs)

~~In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the SGTS. They are addressed as follows:~~

(a) BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ SGT equipment is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the SGTS is in full compliance with this BTP.*

7.3.2.6 Emergency Diesel Generator Support System—Instrumentation and Control

7.3.2.6.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

~~*Table 7.1-2 identifies the emergency diesel generator support systems with the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

(1) 10CFR50.55a (IEEE-~~279~~603)

(4) Branch Technical Positions (BTPs)

~~*In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the diesel generator support systems.*~~

~~*They are addressed as follows:*~~

(a) BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ DG support equipment is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the diesel generator support systems are in full compliance with this BTP.*

7.3.2.7 Reactor Building Cooling Water System and Reactor Service Water System Instrumentation and Controls

7.3.2.7.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

(1) 10CFR50.55a (IEEE-~~279~~603)

The RCW and the RSW Systems are designed to meet all applicable requirements of IEEE-~~279~~603. Detailed system design descriptions are given in Subsection 7.3.1.1.7 and in Section 9.2.

~~Table 7.1-2 identifies the RCW and RSW Systems and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.~~

(4) Branch Technical Positions (BTPs)

~~*In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the RCW System. They are addressed as follows:*~~

(a) BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"

~~*The ABWR design is a single unit*~~*.* RCW equipment is not shared between units. *Therefore, Item B-2 of the BTP is not applicable. Otherwise, the RCW is in full compliance with this BTP.*

7.3.2.8 Essential HVAC Systems—Instrumentation and Control

7.3.2.8.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

STD DEP Admin

~~*Table 7.1-2 identifies the HVAC Systems and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

(1) 10CFR50.55a (IEEE-~~279~~603)

The essential HVAC Systems (HVAC) ~~have two~~ are powered by three *independent electrical divisions and are redundantly designed so that failure* *of any single electrical component will not interfere with the required safety action of the system.*

The HVAC System utilizes mechanical Divisions ~~A & B~~ A, B, and C *corresponding with electrical Divisions ~~I & II,~~* I, II, and III, *respectively. Electrical separation is maintained between the redundant divisions.*

*The HVAC System is designed to meet all applicable requirements of IEEE-~~279~~*603*. Detailed system design descriptions are given in Subsection 7.3.1.1.8 and in Chapter 9.*

(4) Branch Technical Positions (BTPs)

~~*In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the HVAC System. They are addressed as follows:*~~

(a) BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"

~~*The ABWR design is a single unit.*~~ HVAC equipment is not shared between units. *Therefore, item B-2 of the BTP is not applicable. Otherwise, the HVAC System is in full compliance with this BTP.*

7.3.2.9 HVAC Emergency Cooling Water System—Instrumentation and Control

7.3.2.9.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

~~*Table 7.1-2 identifies the HECW System and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.*~~

*(1) 10CFR50.55a (IEEE-~~279~~*603*)*

*The HECW System is designed to meet all applicable requirements of IEEE-~~279~~*603*. Detailed system design descriptions are given in Subsection 7.3.1.1.9 and in Chapter 9.*

(4) Branch Technical Positions (BTPs)

~~*In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the HECW System. They are addressed as follows:*~~

(a) BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"

~~The ABWR design is a single unit.~~ HECW is not shared between units. Therefore, Item B-2 of the BTP is not applicable. Otherwise, the HECW System is in full compliance with this BTP.

7.3.2.10 High Pressure Nitrogen Gas Supply System—Instrumentation and Controls

7.3.2.10.2 Specific Regulatory Requirements Conformance

STP DEP 1.1-2

STD DEP 1.8-1

~~Table 7.1-2 identifies the HPIN System and the associated codes and standards applied in accordance with the Standard Review Plan. The following analysis lists the applicable criteria in order of the listing on the table, and discusses the degree of conformance for each. Any exceptions or clarifications are so noted.~~

(1) *10CFR50.55a (IEEE-~~279~~603)*

The HPIN System is designed to meet all applicable requirements of IEEE- ~~279~~-603. Detailed system design descriptions are given in Subsection 7.3.1.1.10 and in Chapter 6.

(4) *Branch Technical Positions (BTPs)*

~~In accordance with the Standard Review Plan for Section 7.3, and with Table 7.1-2, only BTPs 21 and 22 are considered applicable for the HPIN System. They are addressed as follows:~~

(a) *BTP ICSB 21— "Guidance for Application for Regulatory Guide 1.47"*

~~The ABWR design is a single unit.~~ HPIN is not shared between units. Therefore, Item B-2 of the BTP is not applicable.

7.3.3 COL License Information

7.3.3.1 Cooling Temperature Profiles for Class 1E Digital Equipment

The following standard supplement addresses COL item 7.3-1.

The room profiles for equipment qualification are included in Appendix 3I. These profiles wil be confirmed as part of the pre-operational testing. See Tier 1 Table 3.4~~-1~~ item 14(b).

The following figures are located in Chapter 21:

- Figure 7.3-1 High Pressure Core Flooder IBD (Sheets 2, 5-11, 13-1713-15, 17)
- Figure 7.3-2 Nuclear Boiler System IBD (Sheets 1-101-11, 18, 27, 29-30, 35-3734, 36-37)
- Figure 7.3-3 Reactor Core Isolation Cooling System IBD (Sheets 1-7, 10–17)
- Figure 7.3-4 Residual Heat Removal System IBD (Sheets 1, 3-4, 6, 10-1310-14, 19-20, 20a)
- Figure 7.3-5 Leak Detection and Isolation System IBD (Sheet 1-8,11-12,15-16, 19-20, 23-24, 35-61,35-56, 58-61, 72, 74-77)