

7.2 Reactor Protection (Trip) System (RPS)—Instrumentation and Controls

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

STD DEP T1 2.3-1 (Table 7.2-1, 7.2-2, Figures 7.2-2, 7.2-6, 7.2-9, 7.2-10)

STD DEP T1 3.4-1 (Figures 7.2-2, 7.2-9, 7.2-10)

STD DEP 1.8-1

STD DEP 7.1-1

STD DEP 7.2-4

STD DEP 7.2-6 (Table 7.2-1)

STD DEP 7.6-1

STD DEP 8.3-1

STD DEP Admin

7.2.1 Description

7.2.1.1 System Description

7.2.1.1.1 RPS Identification

STD DEP T1 3.4-1

The Reactor Protection System (RPS) is the overall complex of instrument channels, trip logics, trip actuators and scram logic circuitry that initiate rapid insertion of control rods (scram) to shut down the reactor. The RPS also establishes reactor operating modes and provides status and control signals to other systems and annunciators. To accomplish its overall function, the RPS interfaces with the ~~Essential Multiplexing System~~, Neutron Monitoring System, ~~Process Radiation Monitoring System~~, Control Rod Drive System, Rod Control and Information System, Reactor Recirculation Control System, ~~Process Computer System~~, Plant Computer Function, Nuclear Boiler System and other plant systems and equipment. These interfaces are discussed in detail in the following subsections. The RPS IED is provided as Figure 7.2-9. The RPS IBD is provided as Figure 7.2-10.

7.2.1.1.4 RPS Equipment Design

The following standard supplement addresses design-related information originally provided in Chapter 20 of the reference ABWR DCD.

The RPS design will utilize proven technology to ensure that a sufficient failure rate history is available to support reliability goals.

7.2.1.1.4.1 General RPS Equipment

STD DEP T1 3.4-1

STD DEP Admin

The RPS equipment is divided into four redundant divisions of sensor (instrument) channels, trip logics and trip actuators, and two divisions of manual scram controls and scram logic circuitry. The sensor channels, divisions of trip logics, divisions of trip actuators and associated portions of the divisions of scram logic circuitry together constitute the RPS scram and air header dump (backup scram) automatic initiation logic. The divisions of manual scram controls and associated portions of the divisions of scram logic circuitry together constitute the RPS scram and air header dump manual initiation logic. The automatic and manual scram initiation logics are independent of each other. RPS equipment arrangement is shown in Figure 7.2-2.

(1) Sensor Channels

Equipment within a sensor channel includes primarily sensors (transducers or switches), ~~multiplexers and digital trip modules (DTMs)~~ trip functions (DTFs). The sensors within each channel monitor plant variables (Subsection 7.2.1.1.4.2) ~~and send either analog or discrete output to remote multiplexer units (RMUs) within the associated division of Essential Multiplexing System (EMS) the DTF.~~ Each division of the EMS performs analog to digital conversion on analog signals and sends the digital or digitized analog output values of all monitored variables to the DTF within the associated RPS sensor channel. The ~~DTM DTF~~ in each sensor channel compares individual monitored variable values with trip setpoint values and for each variable sends a separate, discrete (trip/no trip) output signal to all four divisions of trip logics.

All equipment within a sensor channel is powered from the same division of Class 1E power source. However, different pieces of equipment may be powered from separate DC power supplies. Within a sensor channel, sensors themselves may belong to the RPS or may be components of another system. ~~Signal conditioning and distribution performed by the RMUs is a function of the EMS and is discussed in Section 7A.2.~~

(2) Divisions of Trip Logics

Equipment within a division of trip logic includes primarily manual switches, ~~bypass units (BPUs)~~ bypass interlock functions, trip logic units functions (TLUs/TLFs) and output logic units (OLUs). The various manual switches provide the operator means to modify the RPS trip logic for special operation, maintenance, testing and reset. The ~~BPUs~~ bypass interlock functions enforce restrictions on bypassing multiple divisions of related functions. The bypass interlock functions perform bypass and interlock logic for the channel sensors bypass, main steamline isolation trip special bypass and division trip logic unit bypass. These three bypasses are all manually initiated through individual

~~keylock bypass~~ switches within each of the four divisions. Each ~~BPU bypass switch~~ sends a separate bypass signal for all four channels to the ~~TLUTLE~~ in the same division for channel sensors bypass and MSL isolation trip special bypass. Each ~~BPU bypass switch~~ sends the ~~TLUTLE~~ bypass signal to the OLU in the same division.

The ~~TLUs-TLFs~~ perform automatic scram initiation logic based on reactor operating mode, channel and division trip conditions and bypass conditions. Each ~~TLUTLE~~ receives ~~bistable bypass~~ input signals from the ~~BPU bypass switch~~ and various switches in the same division and receives isolated ~~bistable trip~~ inputs from all four sensor channels of RPS and divisions of the NMS.

The OLUs perform division trip, seal-in, reset and trip test function. Each OLU receives bypass inputs from the ~~BPU bypass switch~~, trip inputs from the ~~TLUTLE~~ and various manual inputs from switches within the same division and provides discrete trip outputs to the trip actuators in the same division. Each OLU also receives an isolated discrete division trip reset permissive signal from equipment associated with one of the two divisions of scram logic circuitry.

All equipment within a division of trip logic is powered from the same division of Class 1E power source. However, different pieces of equipment may be powered from separate DC power supplies, and the ~~BPU~~, ~~TLUTLE~~ and OLU within a division must be powered from separate DC power supplies.

7.2.1.1.4.2 Initiating Circuits

STD DEP T1 2.3-1

STD DEP T1 3.4-1

STD DEP 7.2-4

STD DEP 7.6-1

STD DEP Admin

The RPS will initiate a reactor scram when any one or more of the following conditions occur or exist within the plant:

- (7) ~~High Main Steamline Radiation~~ Not Used

The systems and equipment that provide trip and scram initiating inputs to the RPS for these conditions are discussed in the following subsections. With the exception of the NMS (1) and ~~PRRM (7)~~, and the ~~TB trips (5 and 7)~~ all of the building signals (9) and (10), all of the other systems provide sensor outputs through the ~~EMS~~ to the DTE. Analog-to-digital conversion of these sensor output values is done by EMS DTE equipment. NMS and ~~PRRM~~ trip signals are provided directly to the RPS by the NMS and ~~PRRM~~ trip logic units function. The turbine building signals 9 and 10 are hardwired

to connections in the control building. ~~The TB trips (5 and 7) are provided through hardwired connections.~~

(1) Neutron Monitoring System (NMS)

Each of the four divisions of the NMS equipment provides separate, isolated, bistable SRNM trip and APRM trip signals to all four divisions of RPS trip logics (Figure 7.2-5).

(b) APRM Trip Signals

The APRMs of the NMS provide trip signals to the RPS to cover the range of plant operation from a few percent to greater than reactor rated power. ~~Five~~Six conditions monitored as a function of the NMS comprise the APRM trip logic output to the RPS. These conditions are high neutron flux, high simulated thermal power, APRM inoperative, oscillation power range monitor (ORPM) trip, OPRM Inoperative, or reactor core flow rapid coastdown. The specific condition within the NMS that caused the APRM trip output is not detectable within the RPS.

(c) OPRM Trip Signals

The OPRM is a functional subsystem of the APRM in each of the four APRM channels. The OPRM trip outputs are ~~combined with other described with the APRM trip signals to produce the final RPS trip signal above~~. The OPRM detects thermal hydraulic instability; its RPS trip function suppresses neutron flux oscillation prior to the violation of safety thermal limits.

(2) Nuclear Boiler System (NBS) (Figure 7.2-6)

(a) Reactor Pressure

Reactor pressure is measured at four physically separated locations by locally mounted pressure transducers. Each transducer is on a separate instrument line and provides analog equivalent output ~~through the EMS to the DTM DTE~~ in one of four RPS sensor channels. The pressure transducers and instrument lines are components of the NBS.

(b) Reactor Water Level

Reactor water level is measured at four physically separated locations by locally mounted level (differential pressure) transducers. Each transducer is on a separate pair of instrument lines and provides analog equivalent output ~~through the EMS to the DTM DTE~~ in one of the four RPS sensor channels. The level transducers and instrument lines are components of the NBS.

(c) Drywell Pressure

Drywell pressure is measured at four physically separated locations by locally mounted pressure transducers. Each transducer is on a separate instrument line and provides analog equivalent output ~~through the EMS~~ to the ~~DTM~~ DTE in one of the four RPS sensor channels of the NBS.

(d) Main Steamline Isolation (Figure 7.2-4)

Each of the four main steamlines can be isolated by closing either the inboard or the outboard isolation valve. Separate position switches on both of the isolation valves of one of the main steamlines provide bistable output ~~through the EMS~~ to the ~~DTM~~ DTE in one of the four RPS sensor channels. Each main steamline is associated with a different RPS sensor channel. The main steamline isolation valves and position switches are components of the NBS.

(e) High Suppression Pool Temperature

Suppression pool temperature is measured at ~~four~~ physically separated locations by locally mounted sensors. ~~Each sensor is on a separate instrument line and provides analog equivalent of suppression pool temperature to the EMS which,~~ These sensors are monitored by divisional I/O devices which digitize the signals and, in turn, provide ~~provides~~ digitized suppression pool temperature data to the suppression pool temperature monitoring (SPTM) module of SSLG the reactor trip and isolation system (RTIS). ~~SSLG~~ The SPTM module, after processing and averaging the data, provides the trip signal to the corresponding RPS divisional ~~DTM~~ DTE, when the calculated average temperature exceeds the setpoint.

(3) Control Rod Drive (CRD) System (Figure 7.2-6)

(a) CRD Charging Header Pressure

CRD charging header pressure is measured at four physically separated locations by locally mounted pressure transducers. Each transducer is on a separate instrument line and provides analog equivalent output ~~through the EMS~~ to the ~~DTM~~ DTE in one of the four RPS sensor channels. The pressure transducers and instrument lines are components of the CRD System.

(4) ~~Process Radiation Monitoring (PRM) System (Figure 7.2-6)~~ Not Used

~~(a) Main Steamline Radiation~~

~~Main steamline radiation is measured by four separate radiation monitors. Each monitor is positioned to measure gamma radiation in all four main steamlines. The PRM System then provides a separate bistable output to the DTM in each of the four RPS sensor channels.~~

~~The radiation monitors and associated equipment that determine whether or not main steamline radiation is within acceptable limits are components of the PRM System.~~

(6) Reactor Protection System (Figure 7.2-3)

(a) Turbine Stop Valve Closure

Turbine stop valve closure is detected by separate valve stem position switches on each of the four turbine stop valves. Each position switch provides bistable output through hard-wired connections to the ~~DTM~~ DTE in one of the four RPS sensor channels. The turbine stop valves are components of main turbine; however, the position switches are components of the RPS.

(b) Turbine Control Valve Fast Closure

Low hydraulic trip system oil pressure is detected by separate pressure switches on each of the four turbine control valve hydraulic mechanisms. Each pressure switch provides bistable output through hard-wired connections to the ~~DTM~~ DTE in one of the four RPS sensor channels. The turbine control valve hydraulic mechanisms are components of the main turbine; however, the position and pressure switches are components of the RPS.

(c) Manual Scram

Two manual scram switches or the reactor mode switch provide the means to manually initiate a reactor scram independent of conditions within the sensor channels, divisions of trip logics and divisions of trip actuators. Each manual scram switch is associated with one of the two divisions of actuated load power.

~~In addition to the scram initiating variables monitored by the RPS, one bypass initiating variable is also monitored.~~

7.2.1.1.4.3 RPS Logic

STD DEP T1 2.3-1

STD DEP T1 3.4-1

(2) Division Trip Logic ~~Unit~~Function Bypass

A separate, manual, keylock switch in each of the four divisions provides means to bypass that division's trip ~~unit~~function output to the scram logic. The effect of the division trip logic bypass is to reduce the scram logic to a coincidence of two out of three tripped divisions. Interlocks between the four division trip logic bypasses prevent bypass of any two or more division trip logics at the same time. Once a bypass of one division of trip logic has been

established, bypasses of any of the remaining three division trip logics are inhibited.

(3) *MSL Isolation Special Bypass (Figure 7.2-4)*

A separate, manual, keylock switch associated with each of the four sensor channels provides means to bypass the MSL isolation trip output signal from the sensor channel to all four divisions of trip logic. This bypass permits continued plant operation while any one MSL is isolated without causing a half scram condition. The effect of the MSL isolation special bypass is to reduce the MSL isolation trip function in all four divisions of trip logic to a coincidence of two out of three sensor channel MSL isolation trips. Interlocks between the four divisions of trip logic prevent MSL isolation special bypass in any sensor channel when either a channel sensors bypass or a MSL isolation special bypass is present in any other sensor channel. Once a MSL isolation special bypass has been established in one sensor channel, the same bypass is inhibited in the other three channels. This bypass is inhibited in all three remaining channels when any channel sensor bypass exists.

The following standard supplement addresses continued operation with an isolated main steamline.

Continued operation with an isolated MSL is only permitted if an analysis of the effects of flow-induced vibration on the remaining open MSIVs and other critical components in the reactor and steam systems has been performed. Continued plant operation must remain within the bounds of this analysis.

(4) *Trip Logic and Operating Bypasses*

~~*High Main Steamline Radiation Trip (Figure 7.2-6)*~~

~~*A high main steamline radiation trip will occur in each division of trip logic when a main steamline radiation trip condition exists in any two or more unbypassed sensor channels. There are no operating bypasses associated with this trip function.*~~

7.2.1.1.4.4 Redundancy and Diversity

STD DEP T1 3.4-1

Instrument sensing lines from the reactor vessel are routed through the drywell and terminate outside the primary containment. Instruments mounted on instrument racks in the four quadrants of the Reactor Building sense reactor vessel pressure and water level from this piping. Valve position switches are mounted on valves from which position information is required. The sensors for RPS signals from equipment in the Turbine Building are mounted locally. The four battery-powered inverters and divisional 120 VAC power suppliers for the SSLC and RPS are located in an area where they can be serviced during reactor operation. Sensor signals (via the multiplex network) and power cables are routed to four SSLC/RPTIS cabinets (in which RPS

components are located) in the divisional electrical compartments. One logic cabinet is used for each division.

7.2.1.1.4.6 Separation

STD DEP T1 3.4-1

Four independent sensor channels monitor the various process variables listed in Subsection 7.2.1.1.4.2. The redundant sensor devices are separated so that no single failure can prevent a scram. The arrangement of RPS sensors mounted in local racks is shown in Figure 7.2-2. Locations for local RPS racks and panels are shown on the instrument location drawings provided in Section 1.7. ~~Divisional separation is also applied to the Essential Multiplexing System (EMS) D which provides data highways for the sensor input to the logic units. Physically separated cabinets are provided for the four scram logics. Fiber optic cable routing from remote multiplexing units (RMUs) remote digital logic controllers to control room equipment is shown in raceway plans provided by reference in Section 1.7.~~ The criteria for separation of sensing lines and sensors are discussed in Section 7.1.

RPS inputs to annunciators, ~~recorders,~~ and the plant computer function (PCF) are arranged so that no malfunction of the annunciating, recording, or computing equipment or the PCFs can functionally disable the RPS. Direct signals from RPS sensors are not used as inputs to annunciating or data logging equipment or the PCFs. Electrical isolation is provided between the primary signal and the information output by fiber-optic cable interfaces.

7.2.1.1.6 Operational Considerations

7.2.1.1.6.1 Reactor Operator Information

STD DEP T1 3.4-1

(2) Annunciators

Each RPS trip channel input is ~~provided to the Containment Cooling System (CCS) annunciator system~~ annunciated through isolation devices. Trip logic trips, manual trips, and certain bypasses also signal the annunciator system.

(3) Computer Alarms

~~A~~The plant computer printout function (PCF) display identifies each tripped channel; however, status indication at the RPS trip channel device may also be used to identify the individual sensor that tripped in a group of sensors monitoring the same variable.

Upon detection of a status change of any of the preselected sequential events contacts, the sequence-of-events log shall be initiated and shall signal the beginning of an event. This log will include both NSSS and BOP inputs. Changes of state received 5 milliseconds or more apart are sequentially differentiated on the printed log, together with time of occurrence, which shall

~~be printed in hours, minutes, seconds, and milliseconds. Use of the alarm typewriter and computer is not required for plant safety. The printout of trips is particularly useful in routinely verifying the correct operation of pressure, level, and valve position switches as trip points are passed during startup, shutdown, and maintenance operations.~~

7.2.1.1.7 Setpoints

STD DEP T1 2.3-1

Instrument ranges are chosen to cover the range of expected conditions for the variable being monitored. Additionally, the range is chosen to provide the necessary accuracy for any required setpoints and to meet the overall accuracy requirements of the channel.

(9) ~~Main Steamline High Radiation~~ Not Used

~~High radiation in the vicinity of the main steamlines may indicate a gross fuel failure in the core. When high radiation is detected near the steamlines, a scram is initiated to limit release of fission products from the fuel. The high radiation trip setting is selected high enough above background radiation levels to avoid spurious scrams yet low enough to promptly detect a gross release of fission products from the fuel. More information on the trip setting is available in Section 7.3.~~

7.2.1.1.10 Main Control Room Area

STD DEP T1 3.4-1

Virtually all hardware within the RPS design scope is located within the four separate and redundant reactor trip and isolation system (RTIS) cabinets of the safety system logic and control (SSLC) system cabinets in the main control room, except the instrumentation for monitoring turbine stop valve closure and turbine control valve fast closure, and turbine first-stage pressure. The panels are mounted on four separate control complex system steel floor sections which, in turn, are installed in the main control room. The major control switches are located on the principal console.

7.2.1.1.11 Control Room Cabinets and Their Contents

STD DEP Admin

STD DEP T1 3.4-1

The ~~SSLC logic~~ RTIS cabinets of SSLC, which ~~contain~~ containing the RPS for Divisions I, II, III, and IV, include ~~a vertical board~~ input signal cards for each division. The ~~vertical boards~~ input signal cards contain digital and solid-state discrete and integrated circuits used to condition signals transferred to the ~~SSLCRTIS~~ from the EMS. They also contain combinational and sequential logic circuits for the initiation of safety actions and/or alarm annunciation, isolators for electrical and physical separation of circuits used to transmit signals between redundant safety systems or

between safety and non-safety systems, and system support circuits such as power supplies, ~~automatic testing circuits,~~ etc. Load drivers with solid-state switching outputs for actuation solenoids, motor control centers, or switchgear may be located in the control room.

7.2.1.2 Design Bases

STD DEP T1 3.4-1

STD DEP 1.8-1

STD DEP 7.1-1

STD DEP 8.3-1

STD DEP Admin

Design bases information requested by IEEE-279603 is discussed in the following paragraphs. These ~~IEEE-279603~~ design bases aspects are considered separately from those more broad and detailed design bases for this system cited in Subsection 7.1.2.2.

(3) Sensors

A minimum number of LPRMs per APRM are required to provide adequate protective action. This is the only variable that has spatial dependence (IEEE-279603, Paragraph 3-34.6).

(5) Margin Between Operational Limits

The margin between operational limits and the limiting conditions of operation (scram) for the Reactor Protection System are described in Chapter 16. ~~The margin includes the maximum allowable accuracy error, sensor response times, and sensor setpoint drift.~~

(7) Ranges of Energy Supply and Environmental Conditions

The RPS 120 VAC power is provided by the four battery-powered inverters, for the SSLC, each with an alternate Class 1E 120 VAC supply. The batteries, which are designed for a two-hour minimum capacity, have sufficient stored energy to ride through switching transients in the switch yards in order to prevent switching transients from causing a scram. The alternate sources of 120V power are provided to each SSLC bus from transformers powered from the ~~6.9 kV~~ 4.16kV emergency diesel generators. Since there are three diesel generators, the fourth division alternate power originates from the ~~first~~ second division diesel.

(8) Unusual Events

(d) Fires

To protect the RPS in the event of a postulated fire, the RPS trip logics are contained within the four separate independent ~~SSL~~divisional cabinets. The separation of the cabinets and their individual steel construction assures that the RPS functions will not be prevented by a postulated fire within any of the divisional panels. Incombustible or fire retardant materials are used as much as possible. The use of separation and fire barriers ensures that even though some portion of the system may be affected, the RPS will continue to provide the required protective action (Section 9.5).

(9) *Performance Requirements*

A logic combination (two out of four) of instrument channel trips actuated by abnormal or accident conditions will initiate a scram and produce independent logic seal-ins within each of the four logic divisions. The trip conditions will be annunciated and recorded on the ~~process computer~~PCF. The trip seal-in will maintain a scram signal condition at the CRD System terminals until the trip channels have returned to their normal operating range and the seal-in is manually reset by operator action. Thus, once a trip signal is present long enough to initiate a scram and the seal-ins, the protective action will go to completion.

7.2.2.1 Conformance to Design Bases Requirements

STD DEP T1 2.3-1

STD DEP T1 3.4-1

STD DEP 7.1-1

(1) *Design Bases 7.1.2.2(1)(a)*

Table 7.2-1 provides a listing of the sensors selected to initiate reactor scrams and delineates the range for each sensor. ~~Setpoints, and accuracy and response time can be found in Chapter 16~~ The methods for calculating setpoints are described in Chapter 16. Response times are included in the analysis calculation for the design limit. This information establishes the precision of the RPS variable sensors.

(3) *Design Basis 7.1.2.2(1)(c)*

The scram initiated by the main steamline ~~radiation monitoring system~~ isolation valve closure and reactor vessel low-water level (Level 3) satisfactorily limits the radiological consequences of gross failure of the fuel or RCPB. (Chapter 15 evaluates gross failure of the fuel and RCPB). In no case does the release of radioactive material to the environs result in exposures which exceed the guidelines of applicable published regulations.

(7) *RPS Design Basis 7.1.2.2.1(1)(g) through (n)*

The RPS is designed so that it is only necessary for trip variables to exceed their trip setpoints for sufficient length of time to trip the digital trip ~~modules~~ functions and seal-in the associated trip logic. Once this is accomplished, the scram will go to completion regardless of the state of the variable which initiated the protective action.

The ability of the RPS to function properly with a single failure is discussed in Subsection ~~7.2.1.2~~ 7.2.1.1.4.4.

The ability of the RPS to function properly while any one sensor or channel is bypassed or undergoing test or maintenance is discussed in Subsection ~~7.2.1.2~~ 7.2.1.1.4.3.

The following standard supplement addresses the licensing requirements from 7.1.2.2(1).

- (9) Design Basis 7.1.2.2(1)(q), (r) and (s)

Selective automatic and manual operational trip bypasses that permit proper plant operation are provided.

Manual control switches for initiation of reactor scram by plant operator are provided.

Mode switch to allow appropriate operational trips is provided.

7.2.2.1.1 Other Design Basis Requirements

STD DEP T1 3.4-1

- (1) *Control rod status ~~lamps indicating~~ indication of each rod fully inserted.*
- (2) *Control rod scram valve status ~~lamps~~ indicating open valves.*

7.2.2.2.2 Regulatory Guides

STD DEP T1 3.4-1

STD DEP 1.8-1

STD DEP Admin

- (3) *Regulatory Guide 1.53—Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems.*

Compliance with NRC Regulatory Guide 1.53 is met by specifying, designing, and constructing the Reactor Protection System to meet the single-failure criterion described in Section ~~4.25.1~~ of ~~IEEE-279603~~ (~~Criteria for Protection~~ Standard Criteria for Safety Systems for Nuclear Power Generating Stations) and IEEE-379 (Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Class 1E Systems).

Redundant sensors are used and the logic is arranged to ensure that a failure in a sensing element of the decision logic or an actuator will not prevent protective action. Separated channels are employed so that a fault affecting one channel will not prevent the other channels from operating properly. A complete discussion of the RPS power supplies is presented in Subsection 7.2.1.1.

- (4) Regulatory Guide 1.62—Manual Initiation of Protective Actions.

Manual initiation of reactor scram, once initiated, goes to completion as required by IEEE-279603, ~~Section 4.16~~ Sections 5.2 and 7.3.

- (5) Regulatory Guide 1.75—Physical Independence of Electric Systems

The RPS complies with the criteria set forth in IEEE-279603, Paragraph 4.65.6, and Regulatory Guide 1.75, which endorses IEEE-384. Class 1E circuits and Class 1E-associated circuits are identified and separated from redundant and non-Class 1E circuits. Isolation devices are provided in the design where an interface exists between redundant Class 1E divisions and between non-Class 1E and Class 1E or Class 1E-associated circuits. Independence and separation of safety-related systems is discussed in ~~Subsections 8.3.1.3 and 8.3.1.4~~ Subsection 8.3.3.6.2.

Physical and electrical independence of the instrumentation devices of the system is provided by channel independence for sensors exposed to each process variable. Separate and independent raceways are routed from each device to the respective ~~remote multiplexing units (RMUs)~~ I/O devices. Each ~~channel~~ division has a separate and independent control room panel. Trip logic outputs are separated in the same manner as are the channels. Signals between redundant RPS divisions are electrically and physically isolated by Class 1E isolators or by fiber optic cables.

7.2.2.2.3.1 ~~IEEE-279603, Protection~~ Standard Criteria for Safety Systems for Nuclear Power Generating Stations

STD DEP T1 2.3-1

STD DEP 1.8-1

STD DEP T1 3.4-1

STD DEP 7.6-1

STD DEP Admin

The Reactor Protection (trip) System conforms to the requirements of this standard. The following is a detailed discussion of this conformance.

- (1) General Functional Requirement (~~Paragraph 4.4~~ Section 5)

- (2) Single-Failure Criterion (~~Paragraph 4.2~~Section 5.1)
- (3) Quality of Components and Modules (~~Paragraph 4.3~~Section 5.3)
- (4) Equipment Qualification (~~Paragraph 4.4~~Section 5.4)
- (5) ~~Channel System Integrity~~ (~~Paragraph 4.5~~Section 5.5)
- (6) ~~Channel Independence~~ (~~Paragraph 4.6~~Section 5.6)
- (7) Control and Protection System Interaction (~~Paragraph 4.7~~Section 6.3)
- (8) Derivation of System Inputs (~~Paragraph 4.8~~Section 6.4)

The following RPS trip variables are direct measures of a reactor overpressure condition, a reactor overpower condition, a gross fuel damage condition, or abnormal conditions within the reactor coolant pressure boundary:

- (a) Reactor vessel low water level (Level 3) trip
- (b) ~~Main steamline high radiation trip~~ Not Used
- (c) (c) Neutron monitoring (APRM) system trip
 - (i) Neutron flux trip
 - (ii) Simulated thermal power
 - (iii) OPRM trip
 - (iv) Reactor core flow rapid coastdown
 - (v) APRM inoperative
 - (vi) OPRM inoperative
- (d) Neutron Monitoring (SRNM) System trip
 - (i) Neutron flux trip
 - (ii) Short neutron flux period
 - (iii) ~~Channel~~SRNM inoperative
- (9) Capability for Sensor Checks (~~Paragraph 4.9~~Section 5.7)
- (10) Capability for Test and Calibration (~~Paragraph 4.10~~Section 6.5)

Most sensors have a provision for actual testing and calibration during reactor operation. The exceptions are defined as follows:

- (b) ~~Not Used Testing of the main steamline high radiation monitors can be performed during full power operation by cross comparison of sensors. Calibration of the electronics portion of each channel can be performed during reactor operation by switching in a current source in place of the normal signal from the sensor. Calibration of the sensor itself can be performed during shutdown.~~

- (11) Channel Bypass or Removal from Operation (~~Paragraph 4.11~~Section 6.7)
 (12) Operating Bypasses (~~Paragraph 4.12~~Section 6.6)

The following RPS trip variables have no provision for an operating bypass:

- (a) Reactor vessel low water level (Level 3) trip
 (b) ~~Main steamline high radiation trip~~ Not Used

An operating bypass of the low ~~RGSCRD~~ accumulator charging pressure trip is provided in the control room for the operator to bypass the trip outputs during SHUTDOWN and REFUEL modes of operation. Control of this bypass is achieved with bypass switches through administrative means. Its only purpose is to permit reset of the RPS following reactor scram because the low charging water pressure condition would persist until the scram valves are reclosed. The bypass is manually initiated and must be manually removed (via switches or placing the mode switch in STARTUP) to commence withdrawal of control rods after a reactor shutdown.

- (13) Indication of Bypasses (~~Paragraph 4.13~~Section 5.8.3)
 (14) Access to Means for Bypassing (~~Paragraph 4.14~~Section 5.9)
 (15) Multiple Setpoints (~~Paragraph 4.15~~Section 6.8.2)*

The trip setpoint of each SRNM channel is generally fixed. However, there is also the scram initiated by intermediate high neutron flux level corresponding to $5E + 5$ counts per second. This is only activated in a noncoincidence scram mode by a switch in the ~~RPSNMS~~ SSLC cabinet. The conditions under which such trip is to be activated are included in plant operating procedures.

- (16) Completion of Protective Action Once it is Initiated (~~Paragraph 4.16~~Section 7.3)
 (17) Manual Actuation (~~Paragraph 4.17~~Section 7.2)
 (18) Access to Setpoint Adjustments, Calibration, and Test Points (~~Paragraph 4.18~~Section 5.9)

(19) Identification of Protective Actions (~~Paragraph 4.19~~ Section 5.8.2)

When any manual scram pushbutton is depressed, a main control room annunciation is initiated and a ~~process computer system~~ PCE record is produced to identify the tripped RPS trip logic.

Identification of the mode switch in shutdown position scram trip is provided by the ~~process computer system~~ PCE trip logic identification ~~printout~~ record, the mode switch in shutdown position annunciator, and all division trips.

(20) Information Readout (~~Paragraph 4.20~~ Sections 5.8 and 5.14)(21) System Repair (~~Paragraph 4.21~~ Section 5.10)(22) Identification of Protection Systems (~~Paragraph 4.22~~ Section 5.11)

The RPS logic is housed, along with that of the essential core cooling systems and the leak detection and isolation systems, in the reactor trip and isolation system (RTIS) cabinets of safety system logic and control (SSLC) system cabinets. There are four distinct and separate cabinets in accordance with the four electrical divisions. Each division is uniquely identified by color code including cables and associated cables. The SSLC cabinets themselves are clearly marked with the words "~~Safety System Logic and Control~~ Reactor Trip and Isolation System". Each of the component systems controls is clearly identified on the cabinets in accordance with their system grouping and labeling. Control room panels are identified by tags on the panels which indicate the function and identify the contained logic channels. Redundant racks are identified by the identification marker plates of instruments on the racks.

7.2.2.2.4 Conformance to Branch Technical Positions

STD DEP 1.8-1

STD DEP Admin

(4) *BTP-ICSB-26: Requirements for Reactor Protection System Anticipatory Trips*

All hardware components used to provide trip signals to the RPS ~~is~~are designed in accordance with IEEE-279603 and ~~is~~are considered safety-related. This includes the sensors for turbine stop valve closure and turbine control valve fast closure even though these are located in the non-seismic Turbine Building. Since reactor high pressure and power trips are diverse to the turbine scram variables, locating the sensors in the turbine enclosure does not compromise the ability of the RPS to provide protection action when required.

Table 7.2-1 Reactor Protection System Instrumentation Specifications

Reactor vessel high pressure	0-10.3 0-10.0 MPa G	Pressure-transmitter/trip module
Drywell high pressure	0-0.036 MPaG 15.0 - 30.0 kPaG	Pressure-transmitter/trip module
Reactor vessel low water Level 3	0-0.033 MPaG 0 - 1800 mm	Level-transmitter/trip module
Low charging pressure to rod HCU accumulators CRD charging header pressure High	0-245.2 0-20.0 MPa G	Pressure transmitter/ trip module
Turbine stop valve closure	Fully open to fully closed	Position switch
Turbine control valve fast closure	0-10.98 MPa G	Pressure-switch
Main steamline isolation valve closure	Fully open to fully closed	Position-switch
Neutron Monitoring System	APRM or SRNM Trip/No Trip	See Section 7.6
Main steamline high radiation	0.01-10⁴ mGy/h	Gamma-detector
High suppression pool temperature	4 to 110°C 0 to 150°C	Temperature-transmitter/trip module
Turbine first-stage pressure	0 - 6 MPaG	Pressure-transmitter/ trip module

Table 7.2-2 Channels Required for Functional Performance of RPS

This table shows the number of sensors required for the functional performance of the reactor protection system.	
Channel Description	# Sensors
<i>Reactor vessel low level (Level 3)</i>	4
<i>Main steamline radiation</i>	4

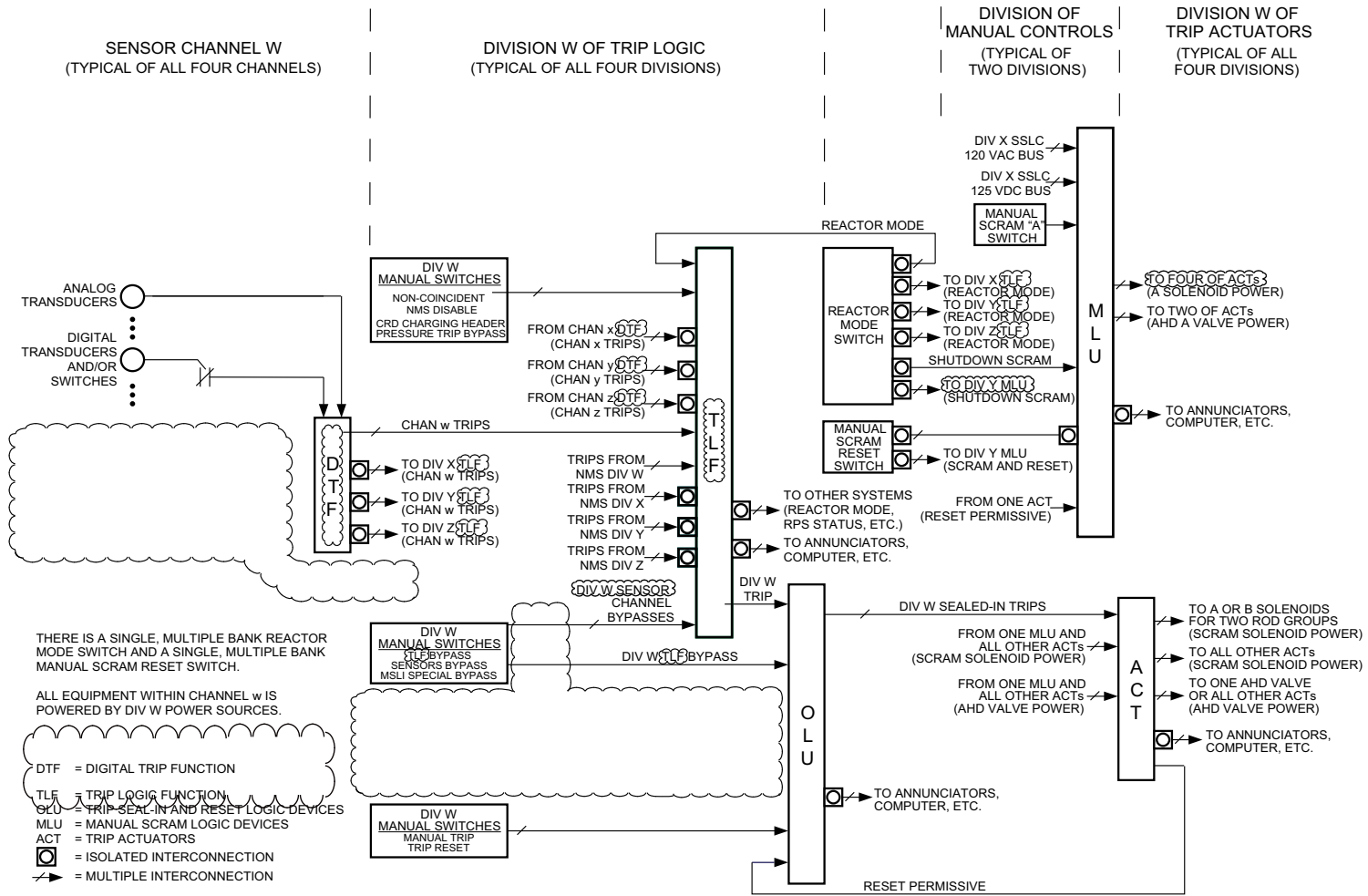
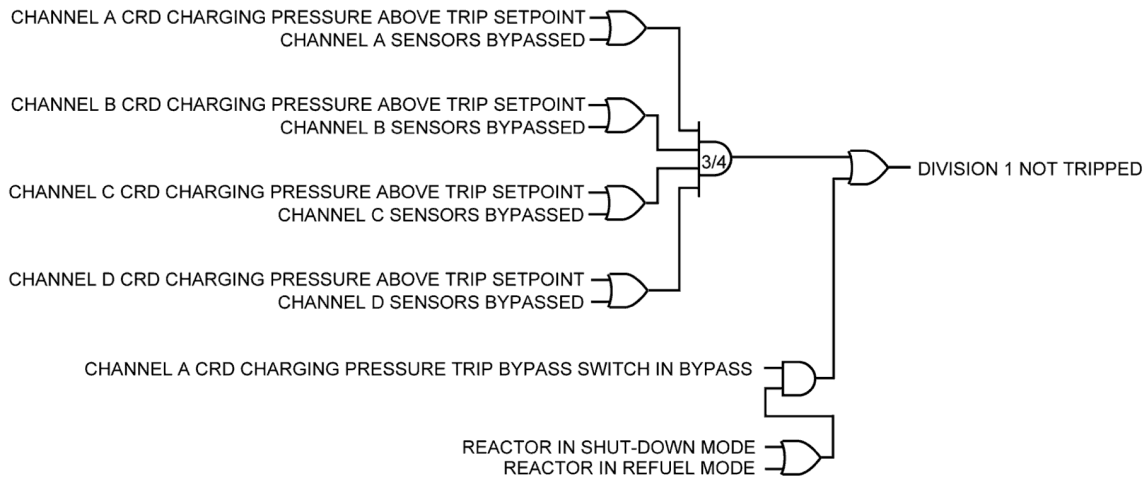
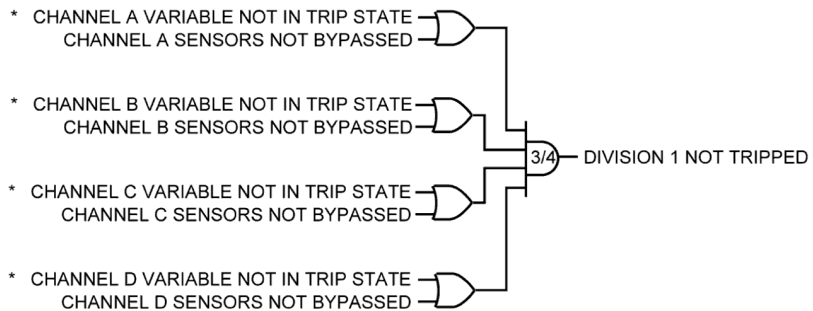


Figure 7.2-2 Reactor Protection System Equipment Arrangement (From Sensors Through Trip Actuators)



LOW CRD CHARGING HEADER PRESSURE
(TYPICAL OF ALL FOUR DIVISIONS)



- * TYPICAL OF
- REACTOR PRESSURE ABOVE TRIP SETPOINT
- REACTOR WATER LEVEL BELOW TRIP SETPOINT
- DRYWELL PRESSURE ABOVE TRIP SETPOINT
- SUPPRESSION POOL TEMPERATURE HIGH

(TYPICAL OF ALL FOUR DIVISIONS)

Figure 7.2-6 Division 1 Trip Logic

The following figures are located in Chapter 21:

- **Figure 7.2-9 (Sheets 1-3, 5, 6)**
- **Figure 7.2-10 (Sheets 1, 2, 11-22, 39-42, 47-54, 69, 71)**

