2.4 Instrumentation of Control Systems

2.4.1 Protection System

1.0 Description

The protection system (PS) is provided to sense conditions requiring protective action and automatically initiate the safety systems required to mitigate the event.

The PS provides the following safety related functions:

- Performs automatic initiation of reactor trip (RT) functions.
- Performs automatic initiation of engineered safety feature (ESF) functions.
- Provides for manual initiation of RT.
- Provides for manual actuation of ESF functions.
- Generates permissive signals that authorize the activation or deactivation of certain protective actions according to current plant conditions.
- Generates permissive signals that maintain safety related interlocks.

2.0 Arrangement

2.1 The location of the safety related PS equipment is as listed in Table 2.4.1-1—Protection System Equipment.

2.2 Physical separation exists between the four divisions of the PS.

3.0 Seismic 1 Classifications

3.1 Equipment identified as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.

4.0 I&C Design Features, Displays and Controls

4.1 The PS generates an automatic RT signal, as identified in Table 2.4.1-3—Protection System Automatic Reactor Trips.

4.2 The PS generates automatically actuated engineered safety feature signals, as identified in Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features.

4.3 The PS provides operating bypasses for the functions identified in Table 2.4.1-6—Protection System Operating Bypasses.

4.4 Communication independence is provided in the inter-division communication paths within the PS.

4.5 Bypassed or inoperable PS channels status information is retrievable in the MCR.

4.6 Setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a methodology that addresses the determination of applicable contributors to instrumentation loop errors, the method in which the errors are combined, and how the errors are applied to the design analytical limits.

4.7 The PS receives input signals from the sources listed in Table 2.4.1-2—Protection System Input Signals.

4.8 The PS provides signals to the non safety related control systems through electrical isolation devices.

4.9 Electrical isolation devices exist in the data communication paths between the PS and the non safety related displays and controls.

4.10 The PS equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to electromagnetic interference (EMI), radio-frequency interference (RFI), electrostatic discharges (ESD), and power surges.

4.11 Controls exist in the MCR and the remote shutdown station (RSS) to allow manual actuation of the manually actuated functions identified in Table 2.4.1-5—Protection System Manually Actuated Functions.

4.12 Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives listed in Table 2.4.1-7—Protection System Permissives.

4.13 The PS interlocks exist as provided in Table 2.4.1-8— Protection System Interlocks.

4.14 The PS hardware and software are developed using a design process with the following life cycle phases:

- Basic design phase.
- Detailed design phase.
- Manufacturing phase.
- Testing phase.
- Installation and commissioning phase.

5.0 Electrical Power

5.1 The equipment identified as Class1E in Table 2.4.1-1 receives power from its respective Class 1E division.

6.0 System Inspections, Tests, Analyses, and Acceptance Criteria

6.1 Table 2.4.1-9—Protection System ITAAC specifies the inspections, tests, analyses, and acceptance criteria for the PS.

Table 2.4.1-1—Protection System Equipment

Equipment Description	Equipment Tag Number (1)	Equipment Location	Seismic Category I	IEEE Class 1E
PS Cabinets, Division 1	30CLE	Safeguard Building 1	Yes	Yes
PS Cabinets, Division 2	30CLF	Safeguard Building 2	Yes	Yes
PS Cabinets, Division 3	30CLG	Safeguard Building 3	Yes	Yes
PS Cabinets, Division 4	30CLH	Safeguard Building 4	Yes	Yes

(1) Equipment Tag numbers are provided for information and are not part of the design certification.

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
1	Neutron Flux from Self Powered Neutron Detectors (SPND)	JKS	4	Yes
2	Neutron Flux from Power Range Detector (PRD)	JKT	4	Yes
3	Neutron Flux from Intermediate Range Detector (IRD)	JKT	4	Yes
4	Rod Control Cluster Assembly (RCCA) positions	JDA	4	Yes
5	Pressurizer (PZR) Pressure-Narrow Range (NR)	JEF	4	Yes
6	PZR Level	JEF	4	Yes
7	Cold Leg Temperature (NR)	JEC	4	Yes
8	Cold Leg Temperature Wide Range (WR)	JEC	4	Yes
9	Hot Leg (HL) Temperature (NR)	JEC	4	Yes
10	Hot Leg Temperature (WR)	JEC	4	Yes
11	Hot Leg Pressure (WR)	JNA	4	Yes
12	Reactor Coolant Pump (RCP) Speed Sensor	JEB	4	Yes
13	RCP power supply current	JEB	4	Yes
14	RCS (Reactor Coolant System) Loop Flow Rate	JEC	4	Yes
15	RCS Loop Level	JEC	4	Yes
16	Chemical and Volume	KBA	4	Yes

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
	Control System (CVCS) Boron Concentration Measurement			
17	CVCS Charging Flow	KBD	4	Yes
18	Steam Generator (SG) Pressure	LBA	4	Yes
19	SG Level (NR)	JEA	4	Yes
20	SG Level (WR)	JEA	4	Yes
21	Containment Equipment Compartments Pressure	KLA	4	Yes
22	Containment Service Compartments Pressure (NR)	KLA	4	Yes
23	Containment Service Compartments Pressure (WR)	KLA	4	Yes
24	Differential Pressure Across RCP	JEC	4	Yes
25	6.9 kV Bus Voltage	BD	4	Yes
26	Reactor Trip Breaker Position	BU	4	Yes
27	Main Steam Line Activity	LBA	4	Yes
28	Main Control Room (MCR) Air Intake Activity	KLK	4	Yes
29	Containment High Range Activity	JYK	4	Yes
30	Manual Reactor Trip	CWY	4	Yes
31	Manual Partial Cooldown Actuation	CWY	4	Yes
32	Manual Main Steam Relief Train (MSRT) Actuation	CWY	4	Yes
33	Manual MSRT Isolation	CWY	4	Yes

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
34	Manual MSIV Isolation	CWY	4	Yes
35	Manual MFW Isolation	CWY	4	Yes
36	Manual Containment Isolation	CWY	4	Yes
37	Manual SG Isolation	CWY	4	Yes
38	Manual MCR Air Intake Isolation and Filtering	CWY	4	Yes
39	Manual EDG Actuation	CWY	4	Yes
40	Manual Safety Injection System (SIS) Actuation	CWY	4	Yes
41	Manual EFWS Isolation	CWY	4	Yes
42	Manual EFWS System Actuation	CWY	4	Yes

Table 2.4.1-3—Protection System Automatic Reactor Trips
RT on Low PZR Pressure
RT on High PZR Pressure
RT on High PZR Level
RT on Low Hot Leg Pressure
RT on Low SG Pressure
RT on High SG Pressure
RT on High SG Pressure Drop
RT on Low SG Level
RT on High SG Level
RT on High Containment Pressure
RT on High Linear Power Density (HLPD)
RT on Low Departure from Nucleate Boiling Ratio (DNBR)
RT on Low DNBR and (Imbalance or Rod Drop)
RT on Low DNBR and Rod Drop
RT on Low DNBR- High Quality
RT on Low DNBR-High Quality and (Imbalance or Rod Drop)
RT on High Neutron Flux Rate of Change
RT on High Core Power Level (HCPL)
RT on Low Reactor Coolant System (RCS) Loop Flow Rate (Two Loops)
RT on Low-Low RCS Loop Flow Rate (One Loop)
RT on Low RCP Speed in Two Loops
RT on High Neutron Flux Intermediate Range (IR)
RT on Low Doubling Time Intermediate Range(IR)
RT on Low Saturation Margin
RT on SIS Actuation
RT on Emergency Feedwater System (EFWS) Actuation

Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features (2 Sheets)

SIS Actuation on Low PZR Pressure
SIS Actuation on Low ΔPSat
SIS Actuation on Low RCS Loop Level
RCP Trip on Low ΔP Over RCP and SIS Signal
Partial Cooldown Actuation on SIS Signal
EFWS Actuation on Low SG Level
EFWS Actuation on LOOP and SIS Actuation
EFWS Isolation on High SG Level
EFWS Isolation on SG Isolation Signal
Main Steam Relief Train (MSRT) Opening on High SG Pressure
MSRT Isolation (MSRIV, MSRCV) on Low SG Pressure
MSRT Setpoint Increase on SG Isolation Signal
Main Steam Isolation Valve (MSIV) Closure on High SG Pressure Drop
MSIV Closure on Low SG Pressure
MSIV Closure on SG Isolation Signal
Main Feedwater (MFW) Full Load Closure on High SG Level
MFW Full Load Closure on RT Confirmation
MFW Full Load and Startup Shutdown Isolation on SG Isolation Signal
MFW Startup and Shutdown Isolation on High SG Pressure Drop
MFW Startup and Shutdown Isolation on Low SG Pressure
MFW Startup and Shutdown Isolation on High SG Level for period of time following RT
Containment Isolation Stage 1 on High Containment Pressure
Containment Isolation Stage 1 on SIS Actuation
Containment Isolation Stage 2 on High Containment Pressure
Containment Isolation on High Containment Activity
EDG Actuation on Low Busbar Voltage
EDG Actuation on SIS Actuation
First PSV Opening on High HL Pressure
Second PSV Opening on High HL Pressure
CVCS Charging Line Shutdown on High PZR Level (two stages)
CVCS Isolation on Anti-Dilution (Shutdown state with no RCP running)
CVCS Isolation on Anti-Dilution (Standard shutdown state)
CVCS Isolation on Anti-Dilution (at power)

Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features (2 Sheets)
SG Isolation on Partial Cooldown signal and High SG Level
SG Isolation on Partial Cooldown signal and High Main Steam Activity
Control Room Heating Ventilation Air Conditioning (HVAC) Isolation and Filtering on High Intake Activity
Turbine Trip on RT Confirmation

Table 2.4.1-5—Protection System Manually Actuated Functions
Reactor Trip
SIS Actuation
Partial Cooldown Actuation
MSRT Actuation
MSRT Isolation
MSIV Isolation
MFW Isolation
Containment Isolation
SG Isolation
Control Room HVAC Isolation and Filtering
EDG Actuation
EFWS Isolation
EFWS Actuation

Table 2.4.1-6—Protection System Operating Bypasses
(2 Sheets)

RT Functions:
RT on High Linear Power Density (HLPD)
RT on Low DNBR
RT on Low DNBR and (Imbalance or Rod Drop)
RT on Low DNBR and Rod Drop
RT on Variable Low DNBR and Insertion Signal
RT on Low DNBR- High Quality
RT on Low DNBR-High Quality and (Imbalance or Rod Drop)
RT on Low Loop Flow Rate (Two Loops)
RT on Low-Low Loop Flow Rate (One Loop)
RT on Low RCP Speed in Two Loops
RT on Low PZR Pressure
RT on HCPL
RT on Low Saturation Margin
RT on High Neutron Flux Intermediate Range
RT on Low Doubling Time Intermediate Range
RT on Low HL Pressure
RT on Low SG Pressure
RT on Low SG Level
RT on High SG Level
RT on EFWS Actuation
RT on High PZR Level
Engineered Safeguard Functions:
SIS Actuation on Low PZR Pressure
SIS Actuation on Low ΔPSat
SIS Actuation on Low RCS Loop Level
CVCS Charging Isolation on High PZR Level
CVCS Isolation on Anti-Dilution (Shutdown state with no RCP running)
CVCS Isolation on Anti-Dilution (Standard shutdown state)
CVCS Isolation on Anti-Dilution (at power)

Table 2.4.1-6—Protection System Operating Bypasses
(2 Sheets)

Partial Cooldown Actuation on SIS Signal
EFWS Actuation on Low SG Level
EFWS Actuation on LOOP and SIS Signals
EFWS Isolation on High SG Level
MSRT Isolation on Low SG Pressure
Main Feedwater (MFW) Full Load Closure on High SG Level
MFW Startup and Shutdown Isolation on High SG Level for period of time following RT
MFW Startup and Shutdown Isolation on Low SG Pressure
MSIV Closure on Low SG Pressure
First PSV Opening on High HL Pressure
Second PSV Opening on High HL Pressure
SG Isolation

Table 2.4.1-7—Protection System Permissives

Permissive	Validation (Manual / Automatic)	Inhibition (Manual / Automatic)
P2	Automatic	Automatic
P3	Automatic	Automatic
P5	Automatic	Automatic
P6	Manual	Automatic
P7	Automatic	Automatic
P8	Automatic	Automatic
P12	Manual	Automatic
P13	Manual	Automatic
P14	Manual	Manual
P15	Manual	Automatic
P16	Manual	Automatic
P17	Manual	Automatic

Table 2.4.1-8—Protection System Interlocks
RHR Suction Valves
MHSI Large Miniflow Line Valves
Safety Injection Accumulator Valves

Table 2.4.1-9—Protection System ITAAC (4 Sheets)

Commitment Wording	Inspection, Analysis or Test	Acceptance Criteria
2.1 PS equipment is located as listed in Table 2.4.1-1.	Inspections will be performed of the location of the PS equipment.	The equipment listed in Table 2.4.1-1 is located as listed in Table 2.4.1-1.
2.2 Physical separation exists between the four divisions of the PS.	Inspections will be performed to verify that the divisions of the PS are located in separate safeguard buildings	The four divisions of the PS are located in separate safeguard buildings.
3.1 Equipment identified as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.	Inspections, type tests, tests, analyses or a combination of tests and analyses will be performed on the equipment designated as Seismic Category I in Table 2.4.1-1.	(1) A report exists and concludes that the equipment listed as Seismic Category I in Table 2.4.1-1 is installed as designed. (2) A report exists and concludes that the equipment listed as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.
4.1 The PS generates an automatic RT signal, as identified in Table 2.4.1-3.	Tests will be performed on the as-built PS using test signals.	The PS generates an automatic RT signal as identified in Table 2.4.1-3.
4.2 The PS generates automatically actuated engineered safety feature signals, as identified in Table 2.4.1-4.	Tests will be performed on the as-built PS using test signals.	The PS generates automatic actuation of engineered safety features, as identified in Table 2.4.1-4.
4.3 The PS provides operating bypasses for the functions identified in Table 2.4.1-6.	Tests will be performed on the as-built PS using test signals.	The PS provides operating bypasses for the functions identified in Table 2.4.1-6.
4.4 Communication independence is provided in the inter-division communication paths within the PS.	Type tests, tests ,analyses or a combination of tests and analyses will be performed on components that establish communication independence in the inter-division communication paths within the PS	A verification and validation (V&V) report exists and concludes that communication independence exists in the inter-division communications paths within the PS.
4.5 Bypassed or inoperable PS channels status information is retrievable in the MCR.	A test of the as built PS will be performed.	Bypassed or inoperable PS channels status information is retrievable in the MCR.

Table 2.4.1-9—Protection System ITAAC (4 Sheets)

Commitment Wording	Inspection, Analysis or Test	Acceptance Criteria
4.6 Setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a methodology that addresses the determination of applicable contributors to instrumentation loop errors, the method in which the errors are combined, and how the errors are applied to the design analytical limits.	An inspection will be performed to verify the existence of a document that describes the methodology for setpoint determination in the PS. An analysis will be performed to verify that the PS setpoints are determined using the documented methodology.	A report exists and concludes that the PS setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a methodology which provides a method: (1) For the determination of applicable contributors to instrument loop error. (2) For combining instrument loop errors. (3) For how the errors are applied to the design analytical limits.
4.7 The PS receives input signals from the sources listed in Table 2.4.1-2.	Tests will be performed using simulated signals.	The PS receives the input signals listed in Table 2.4.1-2.
4.8 The PS provides signals to the non safety related control systems through electrical isolation devices.	Inspections will be performed on the existence of the electrical isolation devices.	Electrical isolation devices exist in the signal path from the PS to the non safety related control systems.
4.9 Electrical isolation devices exist in the data communication paths between the PS and the non safety related displays and controls.	Inspections will be performed on the existence of the electrical isolation devices.	Electrical isolations devices exist in the data communication paths between the PS and the non safety related displays and controls.
4.10 The PS equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.	Type tests, tests, analyses or a combination of these will be performed on the Class 1E equipment listed in Table 2.4.1-1.	A report exists and concludes that the equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.
4.11 Controls exist in the MCR and the RSS to allow manual actuation of the manually actuated functions identified in Table 2.4.1-5.	Inspections and tests will be performed on the existence of controls in the MCR or the RSS to allow manual actuation of the manually actuated functions.	Controls exist in the MCR and RSS to allow manual actuation of the manually actuated functions identified in Table 2.4.1-5.
4.12 Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives	Inspections and tests will be performed on the existence of controls in the MCR and the RSS	Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives

Table 2.4.1-9—Protection System ITAAC (4 Sheets)

Commitment Wording	Inspection, Analysis or Test	Acceptance Criteria
listed in Table 2.4.1-7.	to allow validation or inhibition of manual permissives listed in Table 2.4.1-7.	listed in Table 2.4.1-7.
4.13 The PS interlocks exist as provided in Table 2.4.1-8.	Tests will be performed on the operation of the interlocks listed in Table 2.4.1-8.	The PS interlocks exist as provided in Table 2.4.1-8.
4.14 The PS hardware and software are developed using a design process with the following life cycle phases: • Basic design phase. • Detailed design phase. • Manufacturing phase. • Testing phase. • Installation and Commissioning phase.	Inspections will be performed on the design process for the PS hardware and software development. An analysis will be performed to verify that the PS hardware and software are developed in accordance with the design process.	1a) A design report exists and provides the design outputs of the basic design phase of the PS hardware and software design process. 1b) V&V reports exist that address the Concept and Requirements Activities and conclude that the design outputs generated in the basic design phase conform to the requirements of this phase. 2a) A report exists and provides the design outputs of the detailed design phase of the PS hardware and software design process. 2b) V&V reports exist that address the Design and Implementation Activities and conclude that the design outputs generated in the detailed design phase conform to the requirements of this phase. 3) A report exists and provides the design outputs of the manufacturing phase of the PS hardware and software design process. 4a) A report exists and provides the design outputs of the testing phase of the PS hardware and software design process.

Table 2.4.1-9—Protection System ITAAC (4 Sheets)

Commitment Wording	Inspection, Analysis or Test	Acceptance Criteria
		4b) A V&V report exists that address the Test Activity and concludes that the design outputs generated in the testing phase conform to the requirements of this phase. 5a) A report exists and provides the design outputs of the installation and commissioning phase of the PS hardware and software design process. 5b) A V&V report exists that addresses the Installation and Checkout Activity summary report, if required, for any changes following testing phase and concludes that the design outputs generated in the installation and commissioning phase conform to the requirements of this phase.
5.1 The equipment identified as Class1E in Table 2.4.1-1 receives power from its respective Class 1E division.	Inspections will be performed on the source of power for Class 1E equipment.	The Class 1E equipment listed in Table 2.4.1-1 is powered from its respective Class 1E division.