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ATTENTION: MR. T. R. QUAY

SUBJECT: PROPOSED DRAFT/MARKUP OF SSAR SECTION 7.3

Dear Mr. Quay:

The enclosure provides a draft markup of SSAR Section 7.3. This draft incorporates design changes that have occurred since the original issue of the SSAR.

If you have any questions, please contact Brian McIntyre at (412) 374-4334.

N. J. Liparulo, Manager
Nuclear Safety Regulatory And Licensing Activities

/nja

Enclosure: Draft/Markup of SSAR Section 7.3

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7.3 Engineered Safety Features

AP600 provides instrumentation and controls to sense accident situations and initiate engineered safety features. The occurrence of a limiting fault, such as a loss of coolant accident or a secondary system break, requires a reactor trip plus actuation of one or more of the engineered safety features. This combination of events prevents or mitigates damage to the core and reactor coolant system components, and provides containment integrity.

7.3.1 Description

The protection and safety monitoring system is actuated when safety system setpoints are reached for selected plant parameters. The selected combination of process parameter setpoint violations is indicative of primary or secondary system boundary ruptures. Once the required logic combination is generated, the protection and safety monitoring system equipment sends the signals to actuate appropriate engineered safety features components. A block diagram of the protection and safety monitoring system is provided in Figure 7.1-2.

Subsection 7.1.2 describes the equipment involved in engineered safety features actuation. The equipment consists of the following:

- Sensors and manual inputs
- Integrated protection cabinets
- Engineered safety features actuation cabinets
- Protection logic cabinets
- Actuation devices (such as switchgear, motor control centers, and solenoids)
- Actuated equipment (such as automatic depressurization valves)

The following paragraphs summarize the major functional elements of the protection and safety monitoring system which are involved in generating an actuation signal to an engineered safety features component.

Four sensors normally monitor each variable used for an engineered safety feature actuation. (These sensors may monitor the same variable for a reactor trip function.) Analog measurements are converted to digital form by analog-to-digital converters within each of the four integrated protection cabinets. Following required signal conditioning or processing, the measurements are compared against the setpoints for the engineered safety function to be generated. When the measurement exceeds the setpoint, the output of the comparison results in a channel partial trip condition. The partial trip information is transmitted over isolated data links to the engineered safety features actuation cabinets to form the signals that result in an engineered safety features actuation. The voting logic is performed twice within each engineered safety features actuation cabinet. Each voting logic element generates an actuation signal if the required coincidence of partial trips exists at its inputs.

Within each engineered safety features actuation cabinet, the signals are combined to generate a system-level signal. System-level manual actions are also processed by the logic in each engineered safety features actuation cabinet.

The system-level signals are then broken down to the individual actuation signals through the protection logic cabinets to actuate each component associated with a system level engineered safety feature. For example, a single safeguards actuation signal must trip the reactor and the reactor coolant pumps, align core makeup tank and in-containment refueling water storage tank valves, and initiate containment isolation. The interposing logic within each protection logic cabinet accomplishes this function and also performs necessary interlocking so that components are properly aligned for safety. Component-level manual actions are also processed by this interposing logic. As described in subsection 7.1.2.10, the component level logic, performed within the protection logic cabinets, is triple redundant. The component actuation outputs from the logic processors are combined with the power interface cards in a two-out-of-three voting logic. The power interface also transforms the low level signals to voltages and currents commensurate with the actuation devices they operate. The actuation devices, in turn, control motive power to the final engineered safety feature component.

Subsection 7.3.1.2 provides a functional description of the signals and initiating logic for each of the engineered safety features. Figure 7.2-1 presents the functional diagrams for engineered safety features actuation.

7.3.1.1 Safeguards Actuation (S) Signal

A safeguards actuation (S) signal is used in the initiation logic of many of the engineered safety features discussed in subsection 7.3.1.2. In addition, as described in Section 7.2, the safeguards actuation signal also initiates a reactor trip. The variables that are monitored and used to generate a safeguards actuation signal are typically those that provide indication of a significant plant transient that require a response by several engineered safety features.

The safeguards actuation signal is generated from any of the following initiating conditions:

1. Low pressurizer pressure
2. Low steam line pressure
3. Low reactor coolant inlet temperature
4. High containment pressure
5. Manual initiation

Condition 1 results from the coincidence of pressurizer pressure below the Low setpoint in any two of the four divisions.

Condition 2 results from the coincidence of two of the four divisions of compensated steam line pressure below the Low setpoint in either of the two steam lines. The steam line pressure signal is lead-lag compensated to improve system response.

Condition 3 results from the coincidence of two of the four divisions of reactor coolant system cold leg temperature below the Low setpoint in any two of the four cold legs.

Condition 4 results from the coincidence of two of the four divisions of containment pressure above the High-1 setpoint.

Condition 5 consists of two momentary controls. Manual actuation of either of the two controls will trip the reactor and generate a safeguards actuation signal.

To permit startup and cooldown, the safeguards actuation signals generated from low pressurizer pressure, low steam line pressure, or low reactor coolant inlet temperature can be manually blocked when pressurizer pressure is below the P-11 setpoint. The signal is automatically unblocked above P-11.

Two momentary controls are provided, either of which will manually reset the safeguards actuation signal in all divisions. Manual reset of a safeguards actuation signal in coincidence with reactor trip (P-4) latches to block automatic safeguards actuation. Absence of P-4 automatically resets the blocking function. The safeguards actuation signal is manually reset based on a preset delay following initiation. Resetting the signal does not reposition any safeguards actuated equipment, since individual components are required to latch in and seal on the safeguards actuation signal. The operator can only take manual control of safeguards components actuated by the safeguards actuation signal after the safeguards actuation signal has been reset.

In addition to actuating safety-related functions, a safeguards actuation signal also resets the pressurizer level control setpoint and blocks pressurizer heater operation.

The logic relating to the development of the safeguards actuation signal is illustrated in Figure 7.2-1, sheets 9 and 11.

7.3.1.2 Engineered Safety Feature Descriptions

The following subsections provide a functional description of the signals and initiating logic for each engineered safety feature. Table 7.3-1 lists the signals and summarizes the coincidence logic used to generate the safeguards actuation signal or initiates each engineered safety feature. Table 7.3-2 describes the permissives and interlocks relating to the engineered safety features. Table 7.3-3 lists the system-level manual input to the engineered safety features.

7.3.1.2.1 Containment Isolation

A signal to actuate containment isolation is generated from any of the following conditions:

1. Automatic or manual safeguards actuation signal (subsection 7.3.1.1)
2. Manual initiation
3. Manual actuation of containment cooling (subsection 7.3.1.2.14)

Conditions 1 and 3 are discussed in other subsections as noted.

Condition 2 consists of the manual actuation of either of two momentary controls in the main control room. Either control actuates all divisions and closes the nonessential fluid system paths from the containment. Manual reset of containment isolation latches to defeat the automatic actuation signal for containment isolation. Separate momentary controls are provided for resetting each set of redundant isolation valves.

No interlocks or permissive signals apply directly to the containment isolation function. Automatic actuation originates from a safeguards actuation (S) signal that does contain interlock and permissive inputs.

The functional logic which actuates containment isolation is illustrated in Figure 7.2-1, sheets 11 and 13.

7.3.1.2.2 In-Containment Refueling Water Storage Tank Injection

Signals to align the in-containment refueling water storage tank for injection are generated from the following conditions:

1. Actuation of the first stage of the automatic depressurization system (subsection 7.3.1.2.5)

2. Actuation of the fourth stage of the automatic depressurization system (subsection 7.3.1.2.5)

3. Coincidence loop 1 and loop 2 hot leg levels below setpoint for a duration exceeding an adjustable time delay

4. Manual initiation

Each of the above conditions provide a confirmatory open signal to the in-containment refueling water storage tank discharge isolation valves. These valves are normally open but can be closed by the operator as discussed in subsection 7.6.2.2. The confirmatory open signal automatically overrides any bypass features that are provided to allow the discharge isolation valves to be closed for short periods of time.

Conditions 2, 3, and 4 also open the in-containment refueling water storage tank injection valves, thereby providing a flow path to the reactor coolant system.

Condition 4 consists of two sets of two momentary controls. Manual actuation of both controls of either of the two control sets generate signals that open the in-containment refueling water storage tank discharge isolation and injection valves. A two-control simultaneous actuation prevents inadvertent actuation. Following manual initiation, manual reset is available via redundant momentary controls in the main control room. Operating either control resets all divisions.

No interlocks or permissive apply directly to the discharge isolation and injection valves of the in-containment refueling water storage tank.

The functional logic relating to in-containment refueling water storage tank injection is illustrated in Figure 7.2-1, sheets 15 and 16.

7.3.1.2.3 Core Makeup Tank Injection

Signals to align the core makeup tank for injection are generated from the following conditions:

1. Automatic or manual safeguards actuation (subsection 7.3.1.1)
2. Low pressurizer level
3. Low wide range steam generator level coincident with high hot leg temperature
4. Manual initiation
5. Pressurizer water level increasing above the P-12 interlock

Conditions 1, 2, 3, and 4 trip the reactor and reactor coolant pumps; initiate alignment of the core makeup tank isolation valves for passive injection to the reactor coolant system; and provide a confirmatory open signal to the cold leg balance line isolation valves. The balance line isolation valves are normally open but can be closed by the operator, as discussed in subsection 7.6.2.4. The confirmatory open signal automatically overrides any bypass features that are provided to allow the cold leg balance line isolation valves to be closed for short periods of time. Condition 5 initiates a confirmatory open signal to the cold leg balance line isolation valves. The motive force is provided by density differences between the fluids in the cold leg balance line and the core makeup tank water.

Condition 2 results from the coincidence of pressurizer level below the Low-2 setpoint in any two of the four divisions. This function can be manually blocked when the pressurizer water level is below the P-12 setpoint. This function is automatically unblocked when the pressurizer water level is above the P-12 setpoint.

Condition 3 is derived from a coincidence of:

- The coincidence of both steam generator 1 and 2 wide range level below the low setpoint (derived from two of the four divisions of temperature compensated wide range level for each steam generator), and

- Two of the four divisions of hot leg temperature above the high (T_{hot}) setpoint

Condition 4 consists of two momentary controls. Manual actuation of either of the two controls will align the core makeup tanks for injection. A redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

The functional logic relating to core makeup tank injection is illustrated in Figure 7.2-1, sheet 12.

7.3.1.2.4 Accumulator Injection Alignment

A signal to open the accumulator injection line isolation valves is generated from any of the following conditions:

1. Automatic or manual safeguards actuation (subsection 7.3.1.1)
2. Pressurizer pressure increasing above the P-11 interlock

Conditions 1 and 2 each provide a confirmatory open signal to the accumulator injection line isolation valves. These valves are normally open but can be closed by the operator as discussed in subsection 7.6.2.1. The confirmatory open signal provides a means to automatically override any bypass features that are provided to allow an isolation valve to be closed for short periods of time when the reactor coolant system pressure is greater than the P-11 interlock. Once the isolation valves are opened, check valves direct the flow from the accumulator to the reactor vessel. The motive force is provided by the pressure difference between the accumulator tanks and the reactor coolant system and/or gravity.

The functional logic relating to accumulator injection is illustrated in Figure 7.2-1, sheet 11.

7.3.1.2.5 Automatic Depressurization System Actuation

A signal to actuate the first stage of the automatic depressurization system is generated from any of the following conditions:

1. Core makeup tank injection alignment signal (subsection 7.3.1.2.3) coincident with core makeup tank level less than the Low-1 setpoint in two of the four divisions in either core makeup tank

2. Extended loss of ac power sources

3. Manual initiation

Any actuation of the first stage of the automatic depressurization system also trips the reactor and reactor coolant pumps; actuates the passive residual heat removal heat exchanger; and provides a confirmatory open signal to the in-containment refueling water storage tank discharge isolation valves.

The automatic depressurization system is arranged to sequentially open four parallel stages of valves. Each of the first three stages consists of two parallel paths with each path containing an isolation valve and a depressurization valve. The first three stages are connected to the pressurizer and discharge into the in-containment refueling water storage tank. The fourth stage paths are connected to the hot legs of the reactor coolant system and discharge to containment.

The first stage isolation valves open on any actuation of the first stage of the automatic depressurization system. The first stage depressurization valves are opened following a preset

time delay after the opening of the isolation valves. No interlocks or permissive signals apply directly to the first stage depressurization. However, some safeguards actuation signals, from which the core makeup tank injection actuation signal is derived, do contain interlock and permissive inputs.

The second stage isolation valves are opened following a preset time delay after the first stage depressurization valves open. The second stage depressurization valves are opened following a preset time delay after the second stage isolation valves are opened, similar to stage one. Actuation of the second stage depressurization valves is interlocked with the first stage depressurization actuation signal so that the second stage is not actuated until after the first stage has been actuated.

Similar to the second stage, the third stage isolation valves are opened following a preset time delay after the opening of the second stage depressurization valves. The third stage depressurization valves are opened following a preset time delay after the third stage isolation valves are opened. Actuation of the third stage depressurization valves is interlocked with the second stage depressurization actuation signal such that the third stage is not actuated until after the second stage has been actuated.

The fourth stage of the automatic depressurization system consists of four parallel paths. Each of these paths consist of a normally open isolation valve and a depressurization valve. The four paths are divided into two redundant groups with two paths in each group. Within each group, one path is designated to be substage A and the second path is designated to be substage B.

The fourth stage is actuated upon the coincidence of a low core makeup tank level and low pressurizer pressure following a preset time delay after the third stage depressurization valves are opened. The low core makeup tank level input is based on the core makeup tank level being less than the Low-2 setpoint in two of the four divisions in either core makeup tank. Upon a fourth stage actuation signal, a confirmatory open signal is immediately provided to the substage-A isolation valves. The substage-A depressurization valves are opened following a preset time delay after the substage-A isolation valve confirmatory open signal. The sequence is continued with substage-B. A confirmatory open signal is provided to the substage-B isolation valves following a preset time delay after the substage-A depressurization valve has been opened. The signal to open the substage-B depressurization valve is provided following a preset time delay after the substage-B isolation valves confirmatory open signal. The net effect is to provide a controlled depressurization of the reactor coolant system. In addition to initiating this controlled depressurization sequence, the fourth stage actuation signal also provides a signal that aligns the in-containment refueling water storage tank for injection, as discussed in subsection 7.3.1.2.2.

The fourth stage can also be manually initiated. In this case the manual initiation signal is interlocked with the low pressurizer pressure signal such that the fourth stage manual initiation is prevented until the pressurizer pressure has decreased below a preset setpoint.

Condition 2 results from the loss of both 4160 vac busses for a period of time that approaches the 24 hour Class 1E dc battery capability to activate the automatic depressurization system valves. The timed output holds on restoration of ac power and is manually reset after the batteries are recharged.

Condition 3 is achieved via either of two sets of two momentary controls. If both controls of either set are operated simultaneously, actuation of the automatic depressurization system occurs. A two control simultaneous actuation prevents inadvertent actuation.

Following manual initiation of the automatic depressurization system, manual reset is available via redundant momentary controls in the main control room. Operating either control resets all divisions.

The functional logic relating to automatic depressurization operation is illustrated in Figure 7.2-1, sheet 15.

7.3.1.2.6 Reactor Coolant Pump Trip

A signal to trip reactor coolant pumps is generated from any one of the following conditions:

1. Automatic or manual safeguards actuation signal (subsection 7.3.1.1)

2. Automatic or manual actuation of the first stage of the automatic depressurization system (subsection 7.3.1.2.5)

3. Low pressurizer level

4. Low wide range steam generator level coincident with high hot leg temperature

5. Manual initiation of core makeup tank injection (subsection 7.3.1.2.3)

6. High reactor coolant pump bearing water temperature (trips only affected reactor coolant pump)

Once a signal to trip a reactor coolant pump is generated, the actual tripping of the pump is delayed by a preset time delay. While conditions 1 through 5 trip all four reactor coolant pumps, condition 6 only trips the reactor coolant pump with the high bearing water temperature condition.

Condition 3 results from the coincidence of pressurizer level below the Low-2 setpoint in any two of the four divisions. This function can be manually blocked when the pressurizer water level is below the P-12 setpoint. This function is automatically unblocked when the pressurizer water level is above the P-12 setpoint.

Condition 4 is derived from a coincidence of:

- The coincidence of both steam generator-1 and -2 wide range level below the low setpoint (derived from two of the four divisions of temperature compensated wide range level for each steam generator), and
- Two of the four divisions of hot leg temperature above the high (T_{hot}) setpoint.

Condition 6 is derived from a coincidence of two of the four divisions of high reactor coolant pump bearing water temperature for a single reactor coolant pump. Each reactor coolant pump is tripped independently if Condition 6 is met for its own bearing water temperature. This function is included for equipment protection. The high temperature setpoint and dynamic compensation are the same as used in the high reactor coolant pump bearing water temperature reactor trip (See subsection 7.2.1.1.3) but with the inclusion of preset time delay.

The functional logic relating to the tripping of the reactor coolant pumps is illustrated in Figure 7.2-1, sheets 5, 12, and 15.

7.3.1.2.7 Main Feedwater Isolation

Signals to isolate the main feedwater supply to the steam generators are generated for any of the following conditions:

1. Automatic or manual safeguards actuation (subsection 7.3.1.1)
2. Manual initiation
3. High steam generator narrow-range water level
4. Low reactor coolant system average temperature coincident with P-4 permissive
5. Low-low reactor coolant system average temperature

Conditions 1, 2 and 3 isolate the main feedwater supply by tripping the main feedwater pumps and closing the main feedwater isolation and control valves. These conditions also initiate a turbine trip.

Condition 2 consists of two momentary controls. Manual actuation of either of the two controls will trip the turbine and isolate the main feedwater supply. A redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

Condition 3 is derived from a coincidence of two of the four divisions of compensated narrow range steam generator water level above the High-2 setpoint for either steam generator. In addition to tripping the turbine and isolating the main feedwater supply, condition 3 also initiates a reactor trip, isolates the startup feedwater supply (subsection 7.3.1.2.15), and isolates the chemical volume control system.

Condition 4 results from a coincidence of two of the four divisions of reactor loop average temperature (T_{avg}) below the Low-1 setpoint coincident with the P-4 permissive (reactor trip). This condition results in the closure of the main feedwater control valves. The feedwater

isolation resulting from this condition may be manually blocked when the pressurizer pressure is below the P-11 setpoint.

Condition 5 results from a coincidence of two of the four divisions of reactor loop average temperature (T_{avg}) below the Low-2 setpoint. This condition results in the tripping of the main feedwater pumps and closure of the main feedwater isolation valves. The feedwater isolation resulting from this condition may be manually blocked when the pressurizer pressure is below the P-11 setpoint. The block is automatically removed when the pressurizer pressure is above the P-11 setpoint.

Condition 5 also blocks the steam dump valves and becomes an interlock to the steam dump interlock selector switch. This is discussed in subsection 7.3.1.2.18.

The functional logic relating to the isolation of the main feedwater is illustrated in Figure 7.2-1, sheet 10.

7.3.1.2.8 Passive Residual Heat Removal Heat Exchanger Alignment

A signal to align the passive heat removal heat exchanger to passively remove core heat is generated from any of the following conditions:

1. Core makeup tank injection alignment signal (subsection 7.3.1.2.3)
2. First stage automatic depressurization system actuation (subsection 7.3.1.2.5)
3. Low wide range steam generator level
4. Low narrow range steam generator level coincident with low startup feedwater flow
5. Manual initiation

Each of these conditions open the passive residual heat removal discharge isolation valves and provide a confirmatory open signal to the inlet isolation valve. The inlet isolation valve is normally open but can be closed by the operator. These conditions override any closure signal to this valve and also closes the blowdown isolation valves in both steam generators.

Condition 3 results from the coincidence of two of the four divisions of temperature compensated wide range steam generator level below the Low setpoint in either of the two steam generators.

Condition 4 results from the coincidence of two of the four divisions of temperature compensated narrow range steam generator level below the Low setpoint, after a preset time delay, coincident with a low startup feedwater flow in a particular steam generator. This function is provided for each of the two steam generators. The low narrow range steam generator level also isolates blowdown in the affected steam generator.

Condition 5 consists of two momentary controls. Manual actuation of either of the two controls will align the passive residual heat removal heat exchanger initiating heat removal by this path. A redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

The functional logic relating to alignment of the passive residual heat removal heat exchanger is illustrated in Figure 7.2-1, sheet 8.

7.3.1.2.9 Turbine Trip

A signal to initiate turbir[illegible] trip is generated from any of the following conditions:

1. Automatic [illegible] safeguards actuation signal (subsection 7.3.1.1)
2. Reactor trip (Table 7.3-2, interlock P-4)
3. High steam generator narrow-range water level
4. Manual feedwater isolation (subsection 7.3.1.2.7)

Each of these conditions initiates a turbine trip to prevent or terminate an excessive cooldown of the reactor or minimizes the potential for equipment damage caused by loss of steam supply to the turbine.

Condition 3 results from a coincidence of two of the four divisions of temperature compensated narrow range steam generator water level above the High-2 setpoint for either steam generator.

The functional logic relating to the tripping of the turbine is illustrated in Figure 7.2-1, sheet 14.

7.3.1.2.10 In-Containment Refueling Water Storage Tank Containment Recirculation

Signals to align the in-containment refueling water storage tank (IRWST) containment recirculation isolation valves are generated from the following conditions:

1. Automatic or manual safeguards actuation (subsection 7.3.1.1) in coincidence with low in-containment refueling water storage tank water level

2. Manual initiation

3. Extended loss of ac power sources

There are four parallel containment recirculation paths provided to permit the recirculation of the water provided by the in-containment refueling water storage tank. Two of these paths are provided with two isolation valves in series while the remaining two paths are provided with a single isolation valve in series with a check valve.

Condition 1 and 2 result in the opening of all isolation valves in all four parallel paths. Condition 3 results in the opening of the two isolation valves that are in series with the check valves.

Condition 1 results from the coincidence of two of the four divisions of in-containment refueling water storage tank water level below the Low-5 setpoint, coincident with an automatic or manual safeguards actuation.

Condition 2 consists of two sets of two momentary controls. Manual actuation of both controls of either of the two control sets initiates recirculation in all four parallel paths. A two control simultaneous actuation prevents inadvertent actuation. A redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

Condition 3 results from the loss of both 4160 vac busses for a period of time that approaches the 24 hour Class 1E dc battery capability to activate the in-containment refueling water storage tank containment recirculation isolation valves. The timed output holds on restoration of ac power and is manually reset after the batteries are recharged.

No interlocks or permissives signals apply directly to the activation of the in-containment refueling water storage tank containment recirculation isolation valves. However, automatic actuation may originate from a safeguards actuation signal that does contain interlock and permissive inputs.

The functional logic relating to activation of the in-containment refueling water storage tank containment recirculation isolation valves is illustrated in Figure 7.2-1, sheets 15 and 16.

7.3.1.2.11 Containment Sump pH Control Actuation

Signals to actuate the containment sump pH control tank are generated from the following conditions:

1. Actuation of the automatic depressurization system (subsection 7.3.1.2.5) in coincidence with low in-containment refueling water storage tank water level

2. Manual initiation

Conditions 1 and 2 result in signals that open the vent and injection line valves of the pH tank, allowing the addition of sodium hydroxide to containment water. This maintains the pH of the containment sump in the proper range to reduce the airborne iodine in the containment building and to reduce the potential for stress corrosion cracking of the stainless steel components.

Condition 1 results from the coincidence of two of the four divisions of in-containment refueling water storage tank water level below the Low-3 setpoint, coincident with actuation of the automatic depressurization system.

Condition 2 consists of two sets of two momentary controls. Manual actuation of both controls of either of the two control sets initiates the addition of sodium hydroxide to containment water. A two control simultaneous actuation prevents inadvertent actuation. A

redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

No interlocks or permissives signals apply directly to the activation of the in-containment refueling water storage tank containment recirculation isolation valves. However the automatic depressurization actuation signal may originate from a safeguards actuation signal that does contain interlock and permissive inputs.

The functional logic relating to activation of the in-containment refueling water storage tank containment recirculation isolation valves is illustrated in Figure 7.2-1, sheet 16.

7.3.1.2.12 Steam Line Isolation

A signal to isolate the steam line is generated from any one of the following conditions:

1. Manual initiation
2. High containment pressure
3. Low steam line pressure
4. High steam line pressure negative rate
5. Low reactor coolant inlet temperature

The steam line isolation signal closes the main steam line isolation valves, and the stop and bypass valves. In addition to manual system-level steam line isolation, steam line isolation valves can be closed individually.

Condition 1 consists of two momentary controls. Manual actuation of either of the two controls initiates steam line isolation for both steam generators. In addition, separate controls are provided for steam line isolation of each individual steam generator.

Condition 2 results from the coincidence of two of the four divisions of containment pressure above the High-1 setpoint.

Condition 3 results from the coincidence of two of the four divisions of compensated steam line pressure below the Low setpoint. The steam line pressure signal is lead-lag compensated to improve system response. If the pressure is below this setpoint, in either steam line, both main steam lines are isolated. Also, the block valve for the power-operated relief valve for the affected steam generator is closed.

Condition 4 results from the coincidence of two of the four divisions of rate-lag compensated steam line pressure exceeding the negative rate setpoint.

Condition 5 results from the coincidence of reactor coolant system cold leg temperature below the Low T_{cold} setpoint in any two of the four cold legs.

Steam line isolation for conditions 3 and 5 may be manually blocked when pressurizer pressure is below the P-11 setpoint and is automatically unblocked when pressurizer pressure

is above P-11. Steam line isolation on condition 4 is automatically blocked when pressurizer pressure is above P-11 and is automatically unblocked on the manual blocking of the steam line isolation for conditions 3 and 5. Under all plant conditions, steam line isolation is automatically provided on either Condition 3 or 5, or Condition 4.

Manual reset of automatically actuated steam line isolation signals is available. Operating either of two redundant momentary controls resets all divisions.

The functional logic relating to main steam isolation is illustrated in Figure 7.2-1, sheet 9.

7.3.1.2.13 Steam Generator Blowdown System Isolation

Signals to close the isolation valves of the steam generator blowdown system in both steam generators are generated from the following conditions:

1. Passive residual heat removal heat exchanger alignment signal (subsection 7.3.1.2.8)
2. Low narrow range steam generator level

Condition 2 results from the coincidence of two of the four divisions of temperature compensated narrow range steam generator level below the Low setpoint. This condition only closes the blowdown system isolation valves of the affected steam generator.

The functional logic relating to steam generator blowdown isolation is illustrated in Figure 7.2-1, sheets 7 and 8.

7.3.1.2.14 Containment Cooling Actuation

A signal to actuate the passive containment cooling system is generated from either of the following conditions:

1. Manual initiation
2. High containment pressure

The passive containment cooling system actuation signal opens valves that initiate gravity flow of cooling water from the passive containment cooling system water storage tank to the top of the containment shell. The evaporation of the water on the containment shell provides the passive cooling.

Condition 1 consists of two sets of two momentary controls. Manual simultaneous actuation of both controls in either of the two sets results in manual actuation of the passive containment cooling system. This action also initiates containment isolation (subsection 7.3.1.2.1). A simultaneous actuation prevents inadvertent operation. A redundant manual reset provides the operator with the ability to reset the manual initiation after it has been actuated.

Condition 2 results from a coincidence of two of the four divisions of containment pressure above the High-2 setpoint.

The functional logic relating to actuation of the passive containment cooling system is illustrated in Figure 7.2-1, sheet 13.

7.3.1.2.15 Startup Feedwater Isolation

Signals to isolate the startup feedwater supply to the steam generators are generated from either of the following conditions:

1. Low reactor coolant inlet temperature
2. High steam generator narrow range water level

Either of these conditions isolate the startup feedwater supply by tripping the startup feedwater pumps and closing the startup feedwater isolation and control valves.

Condition 1 results from the coincidence of reactor coolant system cold leg temperature below the Low T_{cold} setpoint in any two of the four cold legs. Startup feedwater isolation on this condition may be manually blocked when the pressurizer pressure is below the P-11 setpoint. This function is automatically unblocked when the pressurizer pressure is above the P-11 setpoint.

Condition 2 results from a coincidence of two of the four divisions of temperature compensated narrow range steam generator water level above the High-2 setpoint for either steam generator.

The functional logic relating to the isolation of the startup feedwater is illustrated in Figure 7.2-1, sheets 9 and 10.

7.3.1.2.16 Boron Dilution Block

Signals to block boron dilution are generated from either of the following conditions:

1. Excessive increasing rate of source range nuclear power
2. Reactor trip (Table 7.3-2, interlock P-4)

The block of boron dilution is accomplished by closing the chemical and volume control system suction valves to demineralized water storage tanks, and aligning the boric acid tank to the reactor coolant system makeup pumps.

Condition 1 is an average of the source range count rate, sampled at least N times over the most recent time period T_1, compared to a similar average taken at time period T_2 earlier. If the ratio of the current average count rate to the earlier average count rate is greater than a preset value, a partial trip is generated in the division. On a coincidence of excessively increasing source range neutron flux in two of the four divisions, boron dilution is blocked.

This source range flux doubling signal may be blocked manually above the P-6 power level. It is automatically reinstated below P-6.

The functional logic relating to the boron dilution block is illustrated in Figure 7.2-1, sheet 3.

7.3.1.2.17 Chemical and Volume Control System Isolation

A signal to close the isolation valves of the chemical and volume control system is generated from either of the following conditions:

1. High pressurizer level
2. High steam generator narrow range water level

Condition 1 results from the coincidence of pressurizer level above the High setpoint in any two of the four divisions. This function is automatically blocked when the pressurizer pressure is below the P-11 permissive setpoint to permit pressurizer water solid conditions with the plant cold and to permit pressurizer level makeup during plant cooldowns. This function is automatically unblocked when pressurizer pressure is above the P-11 setpoint.

Condition 2 results from a coincidence of two of the four divisions of temperature compensated narrow range steam generator water level above the High-2 setpoint for either steam generator.

The functional logic relating to chemical and volume control system isolation is illustrated in Figure 7.2-1, sheet 6.

7.3.1.2.18 Steam Dump Block

Signals to block steam dump (turbine bypass) are generated from either of the following conditions:

1. Low-low reactor coolant system average temperature
2. Manual initiation

Condition 1 results from a coincidence of two of the four divisions of reactor coolant system temperature below the Low-2 setpoint. This blocks the opening of the steam dump valves. This signal also becomes an input to the steam dump interlock selector switch for unblocking the steam dump valves used for plant cooldown. This function may be manually blocked when the pressurizer pressure is below the P-11 setpoint. The block is automatically removed when the pressurizer pressure is above the P-11 setpoint.

Condition 2 consists of two controls. Either one of these controls can be used to manually initiate a steam dump block.

The functional logic relating to the steam dump block is illustrated in Figure 7.2-1, sheet 10.

7.3.1.2.19 Control Room Isolation and Air Supply Initiation

Signals to initiate isolation of the main control room and to initiate the air supply are generated from either of the following conditions:

1. High control room air supply radioactivity level
2. Loss of ac power sources

Condition 1 is the occurrence one of two control room air supply radioactivity monitors detecting a radioactivity level above the High-2 setpoint. The ability to reset this condition is provided in the main control room.

Condition 2 results from the loss of both 4160 ac busses. This condition is delayed by a preset time delay to permit the control room isolation and air supply initiation to be delayed to permit the restoration of ac power from the offsite sources or from the onsite diesel generators.

The functional logic relating to control room isolation and air supply initiation is illustrated in Figure 7.2-1, sheet 13.

7.3.1.2.20 Letdown Purification Line Isolation

A signal to isolate the letdown purification line is generated upon the coincidence of pressurizer level below the Low-2 setpoint in any two of four divisions. This helps to maintain reactor coolant system inventory. The functional logic relating to this is illustrated in Figure 7.2-1, sheet 12.

7.3.1.2.21 Containment Air Filtration System Isolation

A signal to isolate the containment air filtration system is generated upon the coincidence of containment radioactivity above the High-1 setpoint in any two of four divisions. This limits activity release to the environment. The functional logic relating to this is illustrated in Figure 7.2-1, sheet 13.

7.3.1.2.22 Normal Residual Heat Removal System Isolation

A signal for isolating the normal residual heat removal system lines is generated upon the coincidence of containment radioactivity above the High-2 setpoint in any two of four divisions. This limits activity release to the environment. The functional logic relating to this is illustrated in Figure 7.2-1, sheet 13.

7.3.1.3 Blocks, Permissives, and Interlocks for Engineered Safety Features Actuation

The interlocks used for engineered safety features actuation are designated as "P-xx" permissives and are listed in Table 7.3-2.

7.3.1.4 Bypasses of Engineered Safety Features Actuations

The channels used in engineered safety features actuation that can be manually bypassed are indicated in Table 7.3-1. A description of this bypass capability is provided in subsection 7.1.2.10. The actuation logic is not bypassed for test. During tests, the actuation logic is fully tested by blocking the actuation logic output before it results in component actuations.

7.3.1.5 Design Basis for Engineered Safety Features Actuation

The following subsections provide the design bases information for engineered safety features actuation, including the information required by Section 3 of IEEE 279-1971. Engineered safety features are initiated by the protection and safety monitoring system. Those design bases relating to the equipment that initiates and accomplishes engineered safety features are given in subsection 7.1.2.3. The design bases presented here concern the variables monitored for engineered safety features actuation and the minimum performance requirements in generating the actuation signals.

7.3.1.5.1 Design Basis: Generating Station Conditions Requiring Engineered Safety Features Actuation (Paragraph 1 of Section 3 of IEEE 279-1971)

Generating station conditions requiring protective action are identified in Table 7.2-5, that summarizes the engineered safety features as they relate to Condition II, III, or IV events analyzed in Chapter 15.

7.3.1.5.2 Design Basis: Variables, Ranges, Accuracies, and Typical Response Times used in Engineered Safety Features Actuation (Paragraphs 2, 5, 6, and 9 of Section 3 of IEEE 279-1971)

The variables monitored for engineered safety features actuations are:

- Pressurizer pressure
- Pressurizer water level
- Reactor coolant temperature (T_{hot} & T_{cold}) in each loop
- Containment pressure
- Containment radioactivity level
- Steam line pressure in each steam line
- Water level in each steam generator (narrow and wide ranges)
- Source range neutron flux
- Core makeup tank level
- Reactor coolant level in each of the two hot legs
- Loss of ac power sources
- In-containment refueling water storage tank level
- Main control room supply air radioactivity level
- Reactor coolant pump bearing water temperature
- Startup feedwater flow

Subsections 7.3.1.1 and 7.3.1.2 provides a discussion on levels that result in engineered safety features actuation. The allowable values for the limiting conditions for operation and the trip setpoints for engineered safety features actuations are given in the technical specifications (Chapter 16).

Typical ranges, accuracies, and response times for the variables used in engineered safety features actuations are listed in Table 7.3-4. The time response is the maximum allowable time period for an actuation signal to reach the necessary components. It is based on following a step change in the applicable process parameter from five percent below to five percent above (or vice versa) the actuation setpoint with externally adjustable time delays set to OFF.

7.3.1.5.3 Design Basis: Spatially Dependent Variables used for Engineered Safety Features Actuation (Paragraph 3 of Section 3 of IEEE 279-1971)

No spatially dependent variables are used for engineered safety features actuation.

7.3.1.5.4 Design Basis: Limits for Engineered Safety Features Parameters in Various Reactor Operating Modes (Paragraph 4 of Section 3 of IEEE 279-1971)

During startup or shutdown, various engineered safety features actuations can be manually blocked if the pressurizer pressure is below the P-11 setpoint. These functions are listed in Table 7.3-2.

During testing or maintenance of the protection and safety monitoring system cabinets, certain channels used for engineered safety features may be bypassed. Although no setpoints are changed for bypassing, the logic is automatically adjusted, as described in subsection 7.3.1.4. The safeguards channels that can be bypassed in the protection and safety monitoring system are listed in Table 7.3-1.

7.3.1.5.5 Design Basis: Engineered Safety Features for Malfunctions, Accidents, Natural Phenomena, or Credible Events (Paragraph 8 of Section 3 of IEEE 279-1971)

The accidents that the various engineered safety features are designed to mitigate are detailed in Chapter 15. Table 7.2-6 contains a summary listing of the engineered safety features actuated for various Condition II, III, or IV events. It relies on provisions made to protect equipment against damage from natural phenomena and credible internal events. Consequently, there are no engineered safety features actuated by the protection and safety monitoring system to mitigate the consequences of events such as fires.

Functional diversity is used in determining the actuation signals for engineered safety features. For example, a safeguards actuation signal is generated from high containment pressure, low pressurizer pressure and low compensated steam line pressure. Engineered safety features are not normally actuated by a single signal. The extent of this diversity is seen from the initiating signals presented in subsections 7.3.1.1 and 7.3.1.2. Table 7.3-1 also lists the engineered safety features signals and the conditions that result from their actuation.

Redundancy provides confidence that engineered safety features are actuated on demand, even when the protection and safety monitoring system is degraded by a single random failure. The single-failure criterion is met even when engineered safety features channels are bypassed.

7.3.1.6 Final System Drawings

Functional diagrams are provided in Figure 7.2-1.

7.3.2 Analysis for Engineered Safety Features Actuation

7.3.2.1 Failure Modes and Effects Analyses

The failure modes and effects analysis (Reference 1 of Section 7.2) provides an analysis of failures of the protection and safety monitoring system. The protection and safety monitoring system is designed to address common mode failures.

7.3.2.2 Conformance of Engineered Safety Features to the Requirements of IEEE 279-1971

The discussions presented in this subsection address only the functional aspects of actuating engineered safety features. Requirements addressing equipment in the protection and safety monitoring system are presented in subsection 7.1.2.

7.3.2.2.1 Conformance to the General Functional Requirements for Engineered Safety Features Actuation (Paragraph 4.1 of IEEE 279-1971)

The protection and safety monitoring system automatically generates an actuation signal for an engineered safety feature whenever a monitored condition reaches a preset value. The specific engineered safety features actuation functions are listed in Table 7.3-1 and are discussed in subsection 7.3.1.2.

Table 7.3-4 lists the ranges, accuracies, and response times of the parameters monitored. The engineered safety features, in conjunction with a reactor trip, protects against damage to the core and reactor coolant system components, as well as maintaining containment integrity following a Condition II, III, or IV event. Table 7.2-6 summarizes the events that normally result in the initiation of engineered safety features. The setpoints that actuate engineered safety features are listed in the technical specifications (Chapter 16).

7.3.2.2.2 Conformance to the Single Failure Criterion for Engineered Safety Features Actuation (Paragraph 4.2 of IEEE 279-1971)

A single failure in the protection and safety monitoring system does not prevent an actuation of the engineered safety features when the monitored condition reaches the preset value that requires the initiation of an actuation signal. The single failure criterion is met even when one of the engineered safety features actuation cabinets is being tested, as discussed in subsection 7.1.2.10, or when there is a bypass condition in connection with test or maintenance of division(s) in the protection and safety monitoring system.

7.3.2.2.3 Conformance to the Requirements for Channel Independence of the Engineered Safety Features Actuation (Paragraph 4.6 of IEEE 279-1971)

A discussion of channel independence is presented in subsection 7.1.4.2.6. The signals to initiate Division A of the engineered safety features are electrically isolated from the signals to initiate the redundant Divisions (B, C, and D). Divisions of the safeguards actuation system are electrically independent and redundant, as are the power supplies for the divisions up to and including the final actuated equipment.

7.3.2.2.4 Conformance to the Requirements Governing Control and Protection System Interaction of the Engineered Safety Features Actuation (Paragraph 4.7 of IEEE 279-1971)

Discussions are presented on this subject in subsection 7.1.4.2.7.

7.3.2.2.5 Derivation of System Input for Engineered Safety Features Actuation (Paragraph 4.8 of IEEE 279-1971)

To the extent feasible and practical, the protection and safety monitoring system inputs used for actuation of engineered safety features are derived from signals that are direct measures of the desired parameters. The parameters are listed in Table 7.3-4.

7.3.2.2.6 Capability for Sensor Checks and Equipment Test and Calibration of the Engineered Safety Features Actuation (Paragraph 4.9 and 4.10 of IEEE 279-1971)

The discussion of system testability provided in Section 7.1 is applicable to the sensors, signal processing, and actuation logic that initiate engineered safety features actuation.

The testing program meets Regulatory Guide 1.22 as discussed in subsection 7.1.4.2.10. The program is as follows:

- Prior to initial plant operations, engineered safety features tests are conducted.

- Subsequent to initial startup, engineered safety features tests are conducted during each regularly scheduled refueling outage.

- During online operation of the reactor, the protection and safety monitoring system is fully tested as described. In addition, the engineered safety features final actuators, whose operation is compatible with continued online plant operation, are tested at power.

- Continuity of the wiring is verified for those devices that cannot be tested at power without damage or upsetting the plant. Operability of the final actuated equipment is demonstrated at shutdown.

During reactor operation, the basis for acceptability of engineered safety features actuation is the successful completion of the overlapping tests performed on the protection and safety monitoring system. Process indications are used to verify operability of sensors.

7.3.2.2.7 Conformance to Requirements on Bypassing of Engineered Safety Features Actuation Functions (Paragraph 4.11, 4.12, 4.13, and 4.14 of IEEE 279-1971)

Discussions on bypassing are provided in subsections 7.1.4.2.11 through 7.1.4.2.14, and subsection 7.3.1.4.

7.3.2.2.8 Conformance to the Requirement for Completion of Engineered Safety Features Actuation Once Initiated (Paragraph 4.16 of IEEE 279-1971)

Once initiated, engineered safety features proceed to completion unless deliberate operator action is taken to terminate the function on a component-by-component basis. The ability to terminate operation of engineered safety features components is necessary. Components must be turned off and properly aligned if inadvertently actuated. Also, a component may have to be removed from operation for repair or maintenance.

Equipment actuated on a safeguards actuation signal cannot be returned to its previous position for a predetermined number of seconds following initiation of the safeguards actuation signal. At this time a block of the automatic safeguards signal is permitted if the reactor is tripped. This interlock is shown in Figure 7.2-1, sheet 11.

Resetting a system-level safeguards signal does not terminate any safeguards function. Rather, it permits the operator to individually reposition equipment. Equipment cannot be reset until the system-level signal is reset.

7.3.2.2.9 Conformance to the Requirement to Provide Manual Initiation at the System-Level for All Safeguards Actuations (Paragraph 4.17 of IEEE 279-1971)

Manual initiation at the system level exists for the engineered safety features actuations. These system level manual initiations are discussed in subsections 7.3.1.1 and 7.3.1.2.

As a minimum, two controls are provided for each system-level manual initiation so that the protective function can be manually initiated at the system level, despite a single random failure in one control. In certain applications, such as automatic depressurization, two pairs of controls are provided. One pair must be actuated simultaneously. This reduces the likelihood of inadvertent actuation while providing a design that meets the single failure criterion.

7.3.3 Combined License Information

This section has no requirement for information to be provided in support of the Combined License application.

Table 7.3-1 (Sheet 1 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
1. Safeguards Actuation Signal (Figure 7.2-1, Sheets 9 and 11)			
a. Low pressurizer pressure	4	2/4-BYP[1]	Manual block permitted below P-11. Automatically unblocked above P-11.
b. Low lead-lag compensated steam line pressure	4/steam line	2/4-BYP[1] in either steam line	Manual block permitted below P-11. Automatically unblocked above P-11.
c. Low reactor coolant inlet temperature (Low T_{cold})	4/loop	2/4-BYP[1] either loop[6]	Manual block permitted below P-11. Automatically unblocked above P-11.
d. High-1 containment pressure	4	2/4-BYP[1]	None
e. Manual safeguards initiation	2 switches	1/2 switches	Can be manually reset to block safeguards actuation upon P-4. Block automatically removed on absence of P-4.
2. Containment Isolation (Figure 7.2-1 Sheets 11 and 13)			
a. Automatic or manual safeguards actuation signal		(See items 1a through 1e)	
b. Manual initiation	2 switches	1/2 switches	None
c. Manual initiation of containment cooling		(See item 10a)	
3. Automatic Depressurization System (Figure 7.2-1, Sheet 15)			
	(Initiate Stages 1, 2, and 3)		
a. Core makeup tank injection coincident with		(See items 6a through 6d)	
Core makeup tank level less than Low-1 setpoint	4/tank	2/4-BYP[1] either tank[2]	None

Table 7.3-1 (Sheet 2 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
b. Extended undervoltage on 4160V ac buses ECS ES 1 and 2	4/bus	2/4-BYP[1] both busses[5]	None
c. Stages 1, 2, and 3 manual initiation	4 switches	2/4 switches[3]	None
(Initiate Stage 4)			
d. Stage 4 manual initiation coincident with	4 switches	2/4 switches[3]	None
Low pressurizer pressure	4	2/4 BYP[1]	None
e. Core makeup tank level less than Low-2 setpoint coincident with	4/tank	2/4 BYP[1] either tank[2]	None
Low pressurizer pressure and coincident with 3rd stage depressurization	4	2/4 BYP[1]	None
4. Main Feedwater Isolation (Figure 7.2-1, Sheet 10)			
(Closure of Control Valves)			
a. Safeguards actuation signal (automatic or manual)	(See items 1a through 1e)		
b. Manual initiation	2 switches	1/2 switches	None
c. High-2 temperature compensated steam generator narrow range level	4/steam generator	2/4-BYP[1] in either steam generator	None
d. Low reactor coolant temperature (Low-1 T_{avg}) coincident with	2/loop	2/4 -BYP[1]	Manual block permitted below P-11. Automatically unblocked above P-11.
Reactor trip (P-4)	1/division	2/4	None
(Trip of Main Feedwater Pumps and Closure of Isolation Valves)			
a. Safeguards actuation signal (automatic or manual)	(See items 1a through 1e)		

Table 7.3-1 (Sheet 3 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
b. Manual initiation	2 switches	1/2 switches	None
c. High-2 temperature compensated steam generator narrow range level	4/steam generator	2/4-BYP[1] in either steam generator	None
e. Low reactor coolant temperature (Low-2 T_{avg})	2/loop	2/4-BYP[1]	Manual block permitted below P-11. Automatically unblocked above P-11.
5. Reactor Coolant Pump Trip (Figure 7.2-1, Sheets 5, 12 and 15)			
(Trips All Reactor Coolant Pumps)			
a. Safeguards actuation signal (automatic or manual)		(See items 1a through 1e)	
b. Automatic reactor coolant system depressurization (first stage)		(See items 3a through 3c)	
c. Low-2 pressurizer level	4	2/4-BYP[1]	Manual block permitted below P-12. Automatically unblocked above P-12.
d. Low wide range steam generator water level coincident with	4/steam generator	2/4-BYP[1] in both steam generators	None
High reactor coolant outlet temperature (High T_{hot})	2/loop	2/4-BYP[1]	None
e. Manual core makeup tank initiation		(See item 6d)	
(Trip Affected Pump)			
f. High reactor coolant pump water bearing temperature	4/pump	2/4-BYP[1] in affected pump	None
6. Core Makeup Tank Injection (Figure 7.2-1, Sheet 12)			
a. Safeguards actuation signal (automatic or manual)		(See items 1a through 1e)	
b. Low-2 pressurizer level	4	2/4-BYP[1]	Manual block permitted below P-12. Automatically unblocked above P-12.

Table 7.3-1 (Sheet 4 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
c. Low wide range steam generator water level coincident with	4/steam generator	2/4-BYP[1] in both steam generators	None
High reactor coolant outlet temperature (High T_{hot})	2/loop	2/4-BYP[1]	None
d. Manual initiation	2 switches	1/2 switches	None
7. Turbine Trip (Figure 7.2-1, Sheet 14)			
a. Safeguards actuation signal (automatic or manual)		(See items 1a through 1e)	
b. Manual feedwater isolation		(See item 4b)	
c. Reactor trip (P-4)	1/division	2/4	None
d. High-2 temperature compensated steam generator narrow range level	4/steam generator	2/4-BYP[1] in either steam generator	None
8. Steam Line Isolation (Figure 7.2-1, Sheet 9)			
a. Manual initiation	2 switches	1/2 switches	None
b. High-1 containment pressure	4	2/4-BYP[1]	None
c. Low lead-lag compensated steam line pressure[4]	4/steam line	2/4-BYP[1] in either steam line	Manual block permitted below P-11 Automatically unblocked above P-11
d. High steam line negative pressure rate	4/steam line	2/4-BYP[1] either steam line[7]	Manual unblock permitted below P-11 Automatically blocked above P-11
e. Low reactor coolant inlet temperature (Low T_{cold})	4/loop	2/4-BYP[1] either loop[6]	Manual block permitted below P-11 Automatically unblocked above P-11

Table 7.3-1 (Sheet 5 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
9. Steam Generator Blowdown System Isolation (Figure 7.2-1 Sheets 7 and 8)			
a. Passive residual heat removal heat exchanger actuation		(See items 12a through 12e)	
b. Low narrow range steam generator water level	4/steam generator	2/4 BYP[1] in either steam generator	None
10. Containment Cooling (Figure 7.2-1, Sheet 13)			
a. Manual initiation	4 switches	2/4 switches[3] pairs[3]	None
b. High-2 containment pressure	4	2/4-BYP[1]	None
11. Startup Feedwater Isolation (Figure 7.2-1, Sheets 9 and 10)			
a. Low reactor coolant inlet temperature (Low T_{cold})	4/loop	2/4-BYP[1] either loop[6]	Manual block permitted below P-11. Automatically unblocked above P-11.
b. High-2 temperature compensated steam generator narrow range water level	4/steam generator	2/4-BYP[1] in either steam generator	None
12. Passive Residual Heat Removal (Figure 7.2-1, Sheet 8)			
a. Manual initiation	2 switches	1/2 switches	None
b. Low narrow range steam generator water level coincident with	4/steam generator	2/4-BYP[1] in either steam generator	None
Low startup feedwater flow	2/feedwater line	1/2 in either steam line	None
c. Low steam generator wide range water level	4/steam generator	2/4-BYP[1] in either steam generator	None
d. Core makeup tank injection			(See Items 6a through 6d)

Table 7.3-1 (Sheet 6 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
e. Automatic reactor coolant system depressurization (first stage)		(See items 3a through 3c)	
13. Accumulator Injection Unblock (Figure 7.2-1, Sheet 11)			
a. Safeguards actuation signal (automatic or manual)		(See items 1a through 1e)	
b. High pressurizer pressure	4	2/4-BYP[1]	Automatically close isolation valves upon manual initiation of a safeguards block below P-11.
14. Block of Boron Dilution (Figure 7.2-1, Sheet 3)			
a. Flux doubling calculation	4	2/4-BYP[1]	Manual block permitted above P-6. Automatically unblocked below P-6.
b. Reactor trip (P-4)	1/division	2/4	None
15. Chemical Volume Control System Isolation (See Figure 7.2-1, Sheet 6)			
a. High pressurizer water level	4	2/4-BYP[1]	Automatically unblock above P-11. Automatically blocked below P-11.
b. High-2 temperature compensated steam generator narrow range level	4/steam generator	2/4-BYP[1] in either steam generator	None
16. Block Steam Dump (Figure 7.2-1, Sheet 10)			
a. Low reactor coolant temperature (Low-2 T_{avg})	2/loop	2/4-BYP[1]	Manual block permitted below P-11. Automatically unblocked above P-11.
b. Manual block	2 switches	1/division	None
17. Main Control Room Isolation and Air Supply Initiation (Figure 7.2-1, Sheet 13)			
a. High-2 control room supply air radiation	2	1/2	None
b. Extended undervoltage on 4160V ac buses ECS ES 1 and 2	4/bus	2/4-BYP[1] both busses[5]	None

Table 7.3-1 (Sheet 7 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
18. Purification Line Isolation (Figure 7.2-1, Sheet 12)			
a. Low-2 pressurizer level	4	2/4-BYP[1]	Manual block permitted below P-12. Automatically unblocked above P-12.
19. Containment Sump pH Control (Figure 7.2-1, Sheet 16)			
a. Low IRWST level (L-3 setpoint) coincident with	4	2/4-BYP[1]	None
Automatic reactor coolant system depressurization (first stage)		(See items 3a through 3c)	
b. Manual initiation	4 switches	2/4 switches[3]	None
20. Containment Air Filtration System Isolation (Figure 7.2-1, Sheet 13)			
a. High-1 containment radioactivity	4	2/4-BYP[1]	None
21. Normal Residual Heat Removal System Isolation (Figure 7.2-1, Sheet 13)			
a. High-2 containment radioactivity	4	2/4-BYP[1]	None
22. Confirmatory Open IRWST Injection Isolation Valves (Figure 7.2-1, Sheets 15 and 16)			
a. Automatic reactor coolant system depressurization (first stage)		(See items 3a through 3c)	
b. Automatic reactor coolant system depressurization (fourth stage)		(See items 3d through 3e)	
c. Coincident loop 1 and loop 2 low hot leg level (after delay)	1 per loop	2/2	None
d. Manual initiation	4 switches	2/4 switches[3]	None

Table 7.3-1 (Sheet 8 of 8)

ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Actuation Signal	No. of Channels/ Switches	Actuation Logic	Permissives and Interlocks
23. Open IRWST Injection Line Valves (Figure 7.2-1, Sheets 15 and 16)			
a. Automatic reactor coolant system depressurization (fourth stage)		(See items 3d and 3e)	
b. Coincident loop 1 and loop 2 low hot leg level (after delay)	1 per loop	2/2	None
c. Manual initiation	4 switches	2/4 switches[3]	None
24. Open IRWST Containment Recirculation Valves V120A and V120B (Figure 7.2-1, Sheet 16)			
a. Extended undervoltage on 4160V ac buses ECS ES 1 and 2	4/bus	2/4-BYP[1] both busses[5]	None
25. Open All IRWST Containment Recirculation Valves (Figure 7.2-1, Sheet 16)			
b. Safeguards actuation signal (automatic or manual) coincident with		(See items 1a through 1e)	
Low IRWST level (L-5 setpoint)	4	2/4 BYP[1]	None
c. Manual initiation	4 switches	2/4 switches	None

<u>Note:</u>

1. 2/4-BYP indicates automatic bypass logic. The logic is 2 out of 4 with no bypasses; 2 out of 3 with one bypass; 1 out of 2 with two bypasses; and, automatically actuated with three or four bypasses.
2. Any two channels from either tank not in same division.
3. Two switches must be actuated simultaneously.
4. Also, closes power-operated relief block valve of respective steam generator.
5. Any two channels from both busses not in same division.
6. Any two channels from either loop not in same division.
7. Any two channels from either line not in same division.

Table 7.3-2 (Sheet 1 of 3)

INTERLOCKS FOR ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

Designation	Derivation	Function
P-4	Reactor trip switchgear open (reactor trip)	(a) Permits manual reset of safeguards actuation signal to block automatic safeguards actuation (b) Isolates main feedwater if coincident with low reactor coolant temperature (c) Trips turbine (d) Blocks boron dilution
$\overline{\text{P-4}}$	Reactor trip switchgear closed	Automatically resets the manual block of automatic safeguards actuation
P-6	Intermediate range neutron flux channels above setpoint	Allows manual block of flux doubling actuation of the boron dilution block.
$\overline{\text{P-6}}$	Intermediate range neutron flux channels below setpoint	Prevents manual block of flux doubling actuation, permitting block of boron dilution
P-11	Pressurizer pressure below setpoint	(a) Permits manual block of safeguards actuation on low pressurizer pressure,low compensated steam line pressure, or low reactor coolant inlet temperature (b) Permits manual block of steam line isolation on low reactor coolant inlet temperature (c) Permits manual block of steam line isolation and steam generator power-operated relief valve block valve closure on low compensated steam line pressure (d) Coincident with manual actions of (b) or (c), automatically unblocks steam line isolation on high negative steam line pressure rate (e) Permits manual block of main feedwater isolation on low reactor coolant temperature

Table 7.3-2 (Sheet 2 of 3)

INTERLOCKS FOR ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

Designation	Derivation	Function
P-11 (continued)	Pressurizer pressure below setpoint	(f) Automatic block of chemical and volume control system isolation on high pressurizer water level
		(g) Permits manual block of startup feedwater isolation on low reactor coolant inlet temperature
		(h) Permits manual block of steam dump block on low reactor coolant temperature
		(i) Automatically close accumulator injection isolation valves when safeguards block is manually instated
$\overline{\text{P-11}}$	Pressurizer pressure above setpoint	(a) Prevents manual block of safeguards actuation on low pressurizer pressure, low compensated steam line pressure, or low reactor coolant inlet temperature
		(b) Prevents manual block of steam line isolation on low reactor coolant inlet temperature
		(c) Prevents manual block of steam line isolation and steam generator power-operated relief valve block valve closure on low compensated steam line pressure
		(d) Automatic block of steam line isolation on high negative steam line pressure rate
		(e) Prevents manual block of feedwater isolation on low reactor coolant temperature
		(f) Automatic unblock of chemical and volume control system isolation on high pressurizer water level
		(g) Prevents manual block of startup feedwater isolation on low reactor coolant inlet temperature
		(i) Send confirmatory open signal to the accumulator injection line isolation valves

Table 7.3-2 (Sheet 3 of 3)

INTERLOCKS FOR ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

Designation	Derivation	Function
P-12	Pressurizer level below setpoint	(a) Permits manual block of core makeup tank actuation on low pressurizer level to allow mid-loop operation (b) Permits manual block of reactor coolant pump trip on low pressurizer level to allow mid-loop operation (c) Permits manual block of purification line isolation on low pressurizer level to allow mid-loop operation
$\overline{\text{P-12}}$	Pressurizer level above setpoint	(a) Prevents manual block of core makeup tank actuation on low pressurizer level (b) Prevents manual block of reactor coolant pump trip on low pressurizer level (c) Prevents manual block of purification line isolation on low pressurizer level (d) Provides confirmatory open signal to the core makeup tank cold leg balance lines

Table 7.3-3

SYSTEM-LEVEL MANUAL INPUT TO THE ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

Manual Control	To Divisions	Figure 7.2-1 Sheet
Manual safeguards actuation #1	A B C D	2 & 11
Manual safeguards actuation #2	A B C D	2 & 11
Manual passive residual heat removal actuation #1	A B	8
Manual passive residual heat removal actuation #2	A B	8
Manual steam line isolation #1	B D	9
Manual steam line isolation #2	B D	9
Steam/feedwater isolation and safeguards block control #1	B D	9
Steam/feedwater isolation and safeguards block control #2	B D	9
Manual feedwater isolation #1	B D	10
Manual feedwater isolation #2	B D	10
Manual steam dump interlock selector #1	B	10
Manual steam dump interlock selector #2	D	10
Pressurizer pressure safeguards block control #1	A	11
Pressurizer pressure safeguards block control #2	B	11
Pressurizer pressure safeguards block control #3	C	11
Pressurizer pressure safeguards block control #4	D	11
Manual core makeup tank actuation #1	A B C D	12
Manual core makeup tank actuation #2	A B C D	12
Core makeup tank actuation block control #1	A	12
Core makeup tank actuation block control #2	B	12
Core makeup tank actuation block control #3	C	12
Core makeup tank actuation block control #4	D	12
Manual containment cooling actuation #1 & #2	A B	13
Manual containment cooling actuation #3 & #4	A B	13
Manual containment isolation actuation #1	A B C D	13
Manual containment isolation actuation #2	A B C D	13
Manual depressurization system stages 1, 2, and 3 actuation #1 & #2	A B C D	15
Manual depressurization system stages 1, 2, and 3 actuation #3 & #4	A B C D	15
Manual depressurization system stage 4 actuation #1 & #2	A B C D	15
Manual depressurization system stage 4 actuation #3 & #4	A B C D	15
Manual IRWST actuation #1 & #2	A B C D	16
Manual IRWST actuation #3 & #4	A B C D	16
Manual sump PH control actuation #1 & #2	A B C D	16
Manual sump PH control actuation #3 & #4	A B C D	16
Manual containment recirculation actuation #1 & #2	A B C D	16
Manual containment recirculation actuation #3 & #4	A B C D	16

Table 7.3-4 (Sheet 1 of 2)

ENGINEERED SAFETY FEATURES ACTUATIONS, VARIABLES, LIMITS, RANGES, AND ACCURACIES (NOMINAL)

Variable to be Monitored	Range of Variable	Protective System Accuracy	Response Time (Sec)
Pressurizer pressure	1700 to 2500 psig	± 14.5% of span (uncompensated signal)	1.2[1]
Steam line pressure	0 to 1200 psig	± 4.5% of span (inside containment break) ± 10.5% of span (outside containment break)	1.2[1]
Steam line negative pressure rate	0 to 250 psig/sec	± 0.5% of span	1.6[2]
Reactor coolant inlet temperature (T_{cold})	490 to 610°F	± 3.0% of span	6.0[1]
Reactor coolant outlet temperature (T_{hot})	530 to 650°F	± 3.0% of span	6.0[1]
Containment pressure	-5 to 10 psig	± 4.5% of span	1.2[1]
Reactor coolant system hot leg level	0-100% of span	± 3.0% of span	1.6[1]
In-containment refueling water storage tank level	0-100% of span	± 3.0% of span	1.6[1]
4160v ac buses ECS ES 1 and 2 voltage	2000 - 4000 v	±6.5% of setpoint	1.0[1]
Steam generator narrow range water level	0 - 100% of span (narrow range taps)	± 10.0% of span	1.6[1]
Steam generator wide range water level	0-100% of span (wide range taps)	±15.5% of span	1.6[1]
Core makeup tank level	Not applicable (Discrete points)	±1.5 inches	180[3]
Reactor coolant pump bearing temperature	70 - 450°F	± 1.0% of span	2.0[1]

Table 7.3-4 (Sheet 2 of 2)

ENGINEERED SAFETY FEATURES ACTUATIONS, VARIABLES, LIMITS, RANGES, AND ACCURACIES (NOMINAL)

Variables to be Monitored	Range of Variables	Protective System Accuracy	Response Time (Sec)
Pressurizer water level	0 - 100% of cylindrical portion of pressurizer	± 6.0% of span	1.2[(1)]
Startup feedwater flow	0 - 500 gpm	4.0% of span	1.6[(1)]
Neutron flux	1 to 10^6 c/sec	± 5.0% of equivalent linear full scale output	10.0[(1)]
Control room supply air radiation level	10^{-7} - 10^{-2} μ Ci/cc	± 5.0% of full scale	5.0[(1)]
Containment radioactivity	10^0 - 10^7 R/hr	± 5.0% of full scale	5.0[(1)]

Note:

(1) Listed response time is the time for a step change of variable, from 5% below to 5% above the setpoint, to reach the actuated device.

(2) Listed response time is the time for a negative 20% step change of steam line pressure to reach the actuated device.

(3) Listed response time is the time for a step decrease in level, from 1.5 inches above the sensor point to 1.5 inches below the sensor point, to reach the actuated device.

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