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7.3 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

7.3.1 Description

NSSS

The safety-related instrumentation and controls for the engineered safety feature (ESF) systems are those of the engineered safety feature actuation system (ESFAS), which consists of electronic devices, electromechanical relays, and electrical circuits that generate signals that actuate the required ESF systems. The ESFAS includes sensors to monitor selected plant process variables.

The following actuation signals are generated by the ESFAS when the monitored variables reach the levels that indicate conditions requiring protective actions:

a. Containment isolation actuation signal (CIAS)
b. Containment spray actuation signal (CSAS)
c. Main steam isolation signal (MSIS)
d. Safety injection actuation signal (SIAS)
e. Recirculation actuation signal (RAS)
f. Auxiliary feedwater actuation signal (AFAS)

The ESF system actuation device circuitry receives actuation signals from the ESFAS or the operator. The ESFAS signals automatically actuate the ESF systems equipment. The control circuitry for the components provides sequencing necessary to provide proper ESF systems operation.

The actuation circuitry for all ESF systems is essentially identical, except for the sensed parameter and its setpoint. Therefore, the actuation circuits for all ESF HVAC systems are described in one section. The specific

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instrumentation and controls associated with each system are described separately in Subsection 7.3.1.1.10.

BOP

A redundant set of safety-related instrumentation and controls, which is completely separate from the NSSS ESFAS, are provided for proper actuation of the BOP ESF HVAC systems and equipment to mitigate the consequences of the fuel handling accidents in the containment building and the fuel building as well as to provide a habitability condition for the plant operating personnel in the main control complex during all phases of the design-basis events.

The BOP ESFAS consists of safety-related redundant and diversified radiation monitoring sensors strategically located in the containment building, fuel building, and control room air intake; solid-state bistable circuits; and microprocessor-based combination logic circuits which generate the following actuation signals when the monitored variables reach preset levels that require protective actions:

a. Fuel building emergency ventilation actuation signal (FBEVAS)
b. Containment purge isolation actuation signal (CPIAS)
c. Control room emergency ventilation actuation signal (CREVAS)

These actuation signals automatically actuate the following ESF systems:

a. Fuel building emergency exhaust system
b. Containment purge isolation system
c. Control room emergency makeup air system

The manually actuated ESF system is the containment combustible gas control system and is described in Subsection 6.2.5.

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The initiating circuits for all BOP ESF actuation systems are described in Subsection 7.3.1.1. The actuated devices for these systems are described in Subsection 7.3.1.1.10.

7.3.1.1 Engineered Safety Features Actuation System (ESFAS)

NSSS

The actuation system consists of the sensors, logic, and actuation circuits which monitor selected plant parameters and provide an actuating signal to each actuated component in the ESF system required to be actuated if the selected plant parameters reach predetermined setpoints. There is one actuation system for each of the ESF systems; each actuation system is identical except that specific inputs and logic (and blocks, where provided) vary from system to system and the actuated devices are different. The overall logic is shown in Figure 7.3-1.

Within the PPS, the matrix logic is like that shown on Figure 7.2-10. This provides the AB, AC, AD, BC, BD, and CD combinations that create the coincidence of two logics. Each of these matrices operates an initiation circuit that opens the initiation relays. The PPS initiation relays operate corresponding PPS interface relay contacts in the ESFAS-ARC. The combinations of relays 1A and 2A, or 1A and 4A, or 3A and 2A, or 3A and 4A (for the given train shown Figure 7.3-2) changing state, will satisfy the selective two-out-of-four logic and actuate the group actuation relays.

BOP

The BOP ESFAS is tailored to specific requirements and needs of each actuation signal. For generation of the CPIAS, four radiation monitoring sensors from two sets of completely redundant safety-related divisionalized configurations are provided with each set consisting of two diversified and independent

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radiation monitoring sensors. The associated local unit for each sensor contains a solid state bistable circuit and two independent Class 1E isolated output signals, which are transmitted to the divisionalized ILS cabinets over dedicated hardwired cables. In each division of ILS cabinet, a double one-out-of-two microprocessor-based coincidence logic circuit provides the CPIAS for that division. An identical coincidence logic circuit is provided in the other division ILS cabinet.

Four radiation monitoring sensors are also provided for generation of the CREVAS at the control air intake duct. Since the air intake is divisionalized and to take advantage of and to provide flexibility in choosing the air intake point depending upon favorable wind direction, each intake is provided with one set of redundant sensors, each of which is in a different electrical division. The associated bistable circuit in the radiation monitoring local unit provides Class 1E isolated output signal to the ILS cabinet. In the ILS, one-out-of-two coincidence logic circuits provide the CREVAS.

However, the signal combining is done for each divisionalized intake basis first to provided the flexibility mentioned above. The FBEVAS is generated using one set of redundant area-monitoring radiation sensors only to minimize the time lag, and one-of-two coincidence logic circuit is used in each division ILS cabinet. Figure 7.3-3 presents the legend for the signal logic diagram for CREVAS, FBEVAS, and CPIAS shown in Figures 7.3-4, 7.3-5 and 7.3-6.

7.3.1.1.1 <u>ESFAS Measurement Channels</u>

<u>NSSS</u>

Process measurement channels, similar to those described in Subsection 7.2.1.1.2.1, are utilized to perform continuous monitoring of each selected plant process variable, provide indication of operational availability of each

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sensor to the operator, and transmit analog signals to bistables within the ESFAS initiating logic. All protective parameters are measured with four independent process instrument channels.

A typical measurement channel is shown in Figure 7.2-1. It consists of a sensor/transmitter, converter/power supply, indicators, outputs for the plant monitoring system, and interconnecting wiring.

Each measurement channel is separated from other measurement channels to provide physical and electrical separation of the signals to the ESFAS coincidence logic. Cabling is separated within the cabinets and signals to non-Class 1E indicators are isolated. Each channel is supplied from a separate 120-Vac vital distribution bus.

BOP

Each plant parameters for the BOP ESFAS is measured by an independent dedicated process measurement channel.

Process measurement channels are used to perform the following functions:

a. Continuously monitor each selected variable.

b. Provide indication of operation availability of each channel to the operator.

c. Compare the signal recieved from the sensor with a predetermined initiation setpoint in the bistable circuit.

d. Transmit bistable actuation signals to the ESFAS initiating circuit.

A measurement channel consists of instrument sensing lines, sensor, trans-

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mitter, power supplies, bistables, isolation device, indicator, and interconnection wiring.

The bistable circuit in the sensing channel compares the analog signal from the sensor with a predetermined initiation setpoint. If the signal exceeds the setpoint, the bistable output is deenergized. The output signal of the bistable is transmitted to ESFAS actuating logic through an isolation device.

Each measurement channel is separated from other like measurement channels to provide physical and electrical isolation of the signals to the ESFAS actuating logic. The isolation devices prevent a high-voltage fault to either channel A or B sensor outputs from disabling the one-out-of-two initiating logic devices. Cabling is separated within the cabinets and signals to non-Class 1E devices are isolated. Each channel is supplied from a separate Class 1E 120-Vac vital distribution bus.

Display information which provides the operator with the operational availability of each measurement channel is described and tabulated in Section 7.5.

Testing of the ESFAS measurement channels is described in Subsection 7.3.1.1.8.

7.3.1.1.2 Logic

7.3.1.1.2.1 ESFAS Bistable and Coincidence Logic

The NSSS ESFAS bistables are in the plant protection system (PPS) cabinets; the BOP ESFAS bistables are located in the respective radiation monitoring system local units. Therefore the BOP ESFAS bistables area continuation of radiation monitoring sensor measurement channels and the discussion on these bistables are provided in Subsection 7.3.1.1.1.

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Moreover the NSSS ESFAS logic design is based on the electromechanical relay logics. As a result, logic circuit boundaries between the coincidence matrix logics, the initiation logics and the actuating logics are distinct.

On the other hand, the BOP ESFAS logic design is based on microprocessor-based solid-state logics. Hence the coincidence matrix logics, the initiation logics and the actuating logics are simply one programmed logic either in enhanced one-out-of-two or one-out-of-two depending on applications in the BOP ESFAS. Therefore, no such distinction will be made and the terminologies such as initiating logic, coincidence logic, and actuation logic are interchangeably used in the following sections.

NSSS

The ESFAS coincidence logic compares the analog signal from the sensors with predetermined initiation setpoints in the bistable circuit (see Figure 7.2-8). If the signal exceeds the setpoint, the channel bistables output relay deenergizes three trip relays.

The setpoint values are controlled administratively. The setpoints are adjusted at the PPS cabinet. Access to the adjustments is limited by means of a key-operated cover with an annunciator indicating cabinet access. The bistable setpoints are capable of being read out on a meter located on the PPS cabinet. Some setpoints are externally variable to avoid inadvertent initiation during normal operations such as startup, shutdown, and cooldown, and evolutions such as low power testing. The steam generator and pressurizer pressure setpoints can be decreased by pushbuttons and will automatically increase as pressure increases.

The output of the trip relays is formed into the six logic matrices (refer to Figure 7.3-2). The four channels, A, B, C, and D, form into AB, AC, AD, BC, BD, and CD to create all possible coincidence of two combinations. Each logic

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matrix actuates four matrix relays. Six matrix relays (one from each of the six logic matrices) have their output contacts joined in series to form an initiation circuit. Four initiation circuits are used to form four channels 1, 2, 3, and 4. The output of the initiation circuits are initiation relays, A and B, which send signals to the actuation logics in their respective ESF train cabinet.

Besides the automatic actuation of the initiation circuit by the matrix relays, the circuit can be tripped by remote manual switches. All ESFAS can be manually initiated by the operator in accordance with YGN 3&4 procedures. Following initiation, each ESFAS, except AFAS, must be manually reset to restore the initiation logic to the nonactuated state.

BOP

The BOP ESFAS logics are located in the divisionalized Class 1E ILS cabinets, one in each division. The required logic function is software programmed on solid-state microprocessor-based nonvolatile EPROM memories. The logics including the output signals are a positive logic design and consists of one-out-of-two coincidence logics, remote manual initiation features, channel bypasses, and indicating lights.

The BOP ESFAS logics

a. receive ESFAS actuation signals from the bistables,
b. provide a means for remote manual initiation and channel bypass,
c. provide channel and signal status information to the operator, and
d. provide ESFAS initiation signals to each actuation device logic.

The ESFAS signals are also monitored by the plant monitoring system and the plant annunciator system after isolating with fiber optical cables in the ILS cabinet. The contact outputs of the logics provide actuation signal to the

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individual component logic that should be actuated to mitigate consequences of the occurrence which caused the ESFAS. The output signals are transmitted to the ESF system equipment and components. In order to simplify and standardize the logic programming, the actuation logics are categorized in five different types as follows depending upon the actuated equipment:

- o medium-voltage switchgear and load center control (Figure 7.3-7, sh 1 of 5)
- o reversing motor starter control (Figure 7.3-7, sh. 2 of 5)
- o nonreversing motor starter control (Figure 7.3-7, sh. 3 of 5)
- o solenoid valve control (Figure 7.3-7, sh. 4 of 5)
- o electro-hydraulic motor damper control (Figure 7.3-7, sh. 5 of 5)

Each equipment or component has a dedicated microprocessor logic circuit card and no logic circuit is shared. However the transfer function of RSP in division B is controlled through intercommunication data bus in the ILS master control cabinet. There is also a hardwired backup control cabinet described in Subsection 7.3.1.1.6. This is to eliminate the common mode failure affecting more than one equipment or component control function. The control logic on each card is preprogrammed in standard configuration as much as possible to simplify logic programing and minimize programming error based on the above five types. Only the unique equipment control features are left to be programmed at the final stage of the design and implementation. 1

The microprocessor on each card includes self diagnostics of the logic circuit as well as programming features to continuously monitor actuated equipment operating status. Upon detection of a failure, a signal is generated for alarm.

The actuation signal received from the BOP ESFAS or the NSSS ESFAS ARC is provided to the individual component control logic circuit in the ILS through a special logic input on each card which overrides all other signals. This input can only be overridden by a predesigned operating sequence. This component level override feature (ESF Priority 2) is determined based on the ESF system actuated equipment function. A set of ESF system actuated equipment

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of which ESF actuation can never be overridden is called ESF Priority 1.

In the BOP ESFAS, the three actuation signals are independently provided directly to each actuated ESF system equipment or component by the independent dry contact without using group or subgroup relays to improve the reliability and to minimize common mode failure, thus eliminating the probability of an output signal failure affecting more than one ESF equipment control.

Power for each division is supplied from a separate Class 1E 120-Vac power distribution bus and a separate Class 1E 125-Vdc vital power distribution bus.

Testing of logic and actuation paths is described in Subsection 7.3.1.1.8.

7.3.1.1.2.2 Actuating Logic

The NSSS ESFAS actuation logic is physically located in two ESFAS auxiliary relay cabinets. One cabinet contains the logic for ESF Train A equipment, the other cabinet contains the logic for ESF Train B.

The four initiation circuits in the PPS actuate a selective two-out-of-four logic in the ESFAS auxiliary relay cabinets. In an actuation matrix (see Figure 7.3-2), each signal also deenergizes the lockout relays when the selective two-out-of-four logic actuates the train's group actuation relays. The lockout relays ensure that the signal is not automatically reset once it has been initiated.

Receipt of two selective ESFAS initiation channel signals will deenergize the ESF subgroup relays, which generates the actuation channel signals. This is done independently in both ESFAS auxiliary relay cabinets, generating both Train A and Train B signals. The group relays are used to actuate the individual ESF components which should be actuated to mitigate the consequences of the occurrence which caused the ESFAS.

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In the BOP ESFAS, no group or subgroup relays are used in the logics as described in Subsection 7.3.1.1.2.1.

7.3.1.1.2.3 Group Actuation

The group relays actuate the ESF system components required by the ESFAS. These generally consist of either solenoid-operated valves, motor-operated valves, or pump motors. Figures 7.3-8, 7.3-9 and 7.3-10 show how each of these components can be operated by the ESFAS signals.

In Figure 7.3-8, which shows a typical function control logic diagram (FCLD) for a solenoid operated valve with ESF override, the valve closes upon receipt of an RAS from the ESFAS-ARC. The ESF signal causes reset of the component control S/R flip-flop and logic 0 on the component energize-to-open input. Following clearance of the RAS, the component remains in the ESF actuated state and must be reset by applying an open logic signal from either the MCB or RSP. During an ESF actuation the MCB or RSP controls can override the RAS by application of two signals. A close signal sets the override logic S/R flip-flop disabling the RAS, and a subsequent open signal sets the component control S/R flip-flop providing an energize to open signal .(logic 1) to the component.

In Figure 7.3-8, which shows a typical FCLD for a solenoid-operated valve with no ESF override, the component control by the ESFAS-ARC actuation cannot be overridden. The valve closes on an SIAS or CIAS. Following clearance of the safety actuation, SIAS and/or CIAS, the component remains in the actuated state and must be reset by applying an open logic signal from either the MCB or RSP.

In Figure 7.3-9, which shows a typical FCLD for a full-throw motor-operated valve, the valve closes upon receipt of an RAS from the ESFAS-ARC. The ESF signal causes a logic 1 on the component's energize-to-close input and a logic

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0 on the energize-to-open input. Following clearance of the RAS, the component remains in the ESF, actuated state and must be reset by applying an open logic signal from the MCB. During an ESF, actuation the MCB control can override the RAS by application of two signals. A close signal (logic 1) sets the override logic S/R flip-flop disabling the RAS; a subsequent open signal changes the state of the component control S/R flip-flops, enabling a logic 1 on the energize-to-open input and a logic 0 on the energize-to-close input to the component.

In Figure 7.3-10, which shows a typical FCLD for a circuit-breaker-operated component, the circuit breaker closes upon receipt of an SIAS from the ESFAS-ARC to start the pump. The ESF signal causes a logic 1 on the component's close-breaker input and a logic 0 on the open-breaker input. Following clearance of the SIAS, the component remains in the ESF-actuated state and must be reset by applying a stop logic signal from the MCB. During an ESF, acutation of the MCB control can override the SIAS by application of two signals. A start signal sets the override logic S/R flip-flop, disabling the SIAS, and a subsequent stop signal results in a logic 1 on the component's open-breaker input and a logic 0 on the close-breaker input.

If components have to be sequenced, the sequencing will be done in the components' control circuits. Sequencing is described in Subsection 7.3.1.1.7.

7.3.1.1.3 Bypasses

7.3.1.1.3.1 Channel Bypass

NSSS

Bypasses are provided in the plant protection system (PPS), as shown in Table 7.3-1. The trip channel bypass is identical to the RPS trip channel bypass

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(Subsection 7.2.1.1.5) in that it is employed for maintenance and testing of a channel.

BOP

Channel bypasses are provided in the one-out-of-two ESFAS, as shown in Table 7.3-2. The channel bypass is similar to the RPS trip channel bypass and is employed to remove a channel from service for mainten- ance. The coincidence logic is thus converted to a single active channel for the trip type bypassed. Other type of actuations that do not have bypasses in either of their two channels remain in a one-out-of-two logic. The bypass time interval for maintenance is so short that the probability of failure of the remaining channel is acceptably low during maintenance bypass periods. The bypass is manually initiated and manually removed. An administrative procedure allows only one channel for any one type trip to be bypassed at one time. Bypasses are annunciated visually and audibly to the operator.

In some cases, bypass of more than one parameter within a channel may be required in the event of an equipment failure. Specific requirements are provided in ~~Chapter 16, Technical Specifications~~ ITS.

7.3.1.1.3.2 Operating Bypass

The low pressurizer pressure bypass as shown in Figure 7.3-1 is provided to allow plant depressurization without initiating protective actions when not desired. The bypass may be initiated manually in each protective channel. However, the bypass cannot be initiated if pressurizer pressure is greater than that shown in Table 7.3-1. Once the bypass is initiated, it is automatically removed when pressurizer pressure increases above the value shown in Table 7.3-1.

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7.3.1.1.4 Interlocks

The ESFAS interlocks, located in the PPS, prevent the operator from bypassing more than one trip channel of a trip parameter at a time. Different trip parameters may be bypassed simultaneously, either in the same channel or in different channels. This function is shown in Figure 7.2-12.

During system testing, an electrical interlock prevents more than one set of four matrix relays from being held at one time. The same circuit will allow only one process measurement loop signal to be perturbed at a time for testing. The matrix relay hold and loop perturbation switches are interlocked so that only one or the other may be used at any one time.

In the BOP ESFAS, no bypass permissive interlock is provided since bypassing more than one channel disables the actuation of the BOP ESFAS.

7.3.1.1.5 Redundancy

NSSS

There are many redundant features within the ESFAS. There are four independent channels for each parameter from process sensor through and including the initiation circuits located in four PPS bays. There are six logic matrices to actuate the initiation circuits, each of which has two power supplies for the four logic relays of each matrix.

In the ESFAS auxiliary relay cabinets the selective two-out-of-four logic matrix has two power supplies per leg. Each auxiliary relay cabinet controls one ESF system train, and there are two totally redundant auxiliary relay cabinets used to operate two totally redundant ESF trains.

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Overall, the entire ESFAS receives vital ac power from four separate buses and the power for control and operation of separate trains comes from separate buses.

The result is a system which meets the single failure criterion and can be tested during operation and shifted to two-out-of-three logic when a channel is removed for testing or maintenance without affecting system availability.

BOP

Redundant features of the BOP ESFAS include the following:

a. Two independent channels, from process sensor/transmitter through and including bistable output contacts, are provided.

b. Two actuation paths are present for each actuation signal.

c. Each actuation signal actuates two output trains through appropriate isolation devices.

d. Power for the system is provided from two separate buses. Power for control and operation of redundant actuated components comes from separate buses. Train A components and systems are energized only by the Train A bus and Train B components and systems are energized only by the B bus.

The result of the redundant features is a system that meets the single failure criterion and can be tested during plant operation.

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7.3.1.1.6 Diversity

NSSS

The system is designed to eliminate credible multiple channel failures originating from a common cause. The failure modes of redundant channels and the conditions of operation that are common to them are analyzed to ensure that a predictable common failure mode does not exist.

The design provides reasonable assurance that the protective system cannot be made inoperable by the inadvertent actions of operating or maintenance personnel. The design is not encumbered with additional channels or components without reasonable assurance that such additions are beneficial.

BOP

The BOP ESFAS is designed to eliminate credible dual channel failures originating from a common cause. The failure modes of redundant channels and the conditions of operation that are common to them are analyzed to provide reasonable assurance of the following:

a. The monitored variables provide adequate information during the accidents.

b. The equipment can perform as required.

c. The interactions of protective actions, control actions, and environmental changes that cause, or are caused by, the design-basis events do not prevent the mitigation of the consequences of the event.

d. The system cannot be made inoperable by the inadvertent actions of operating and maintenance personnel.

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The design is not encumbered with additional components or channels without reasonable assurance that such additions are beneficial. 1

In addition, a hardwired backup panel is provided as an added assurance for defense against a common mode failure in micro-processor based ILS system.

To ensure hot shutdown of the plant in such an event, a backup panel is provided containing hardwired circuits. These circuits completely bypass the ILS for selected loops. 1

7.3.1.1.7 Sequencing

There is no sequencing for any ESF equipment other than that necessary for ESF bus loading. The automatic load sequencer is discussed below, and for more details, refer to Section 8.3.

Each emergency diesel generator is automatically started and runs unloaded by receipt of safety injection actuation signal, auxiliary feedwater actuation signal, or containment spray actuation signal from the NSSS ESFAS or loss-of-offsite power (LOOP) signal from 4.16-KV Class 1E bus. Receipt of an SIAS or a LOOP signal at the 4.16-KV Class 1E bus automatically initiates the sequencer. Following the LOOP signal, when diesel generator reaches rated voltage and frequency, the diesel generator breaker closes and the sequencer generates the proper signal to connect the ESF equipment to the Class 1E bus in the programmed time sequence. The diesel generator is able to accept loads within 10 seconds after the receipt of the diesel generator start signal. All ESF equipment is connected to Class 1E bus within 50 seconds after diesel generator start signal upon LOOP alone or LOOP concurrent with LOCA.

The control logic diagram is shown in Figure 7.3-11. A detailed list of equipment activated by the load sequencer signal is shown on Table 7.3-16, item 4.

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7.3.1.1.8 Testing

NSSS

Provisions are made to permit periodic testing of the complete ESFAS. These tests cover the trip actions from sensor input through the protection system and actuation devices. The system test does not interfere with the protective function of the system. Overlap between individual tests exists so that the entire ESFAS can be tested.

The testing system meets the criteria of IEEE 338-1977, "IEEE Standard Criteria for the Periodic Testing of Nuclear Power Generating Station Protective Systems," and of Regulatory Guide 1.22, "Periodic Testing of Protection System Actuator Functions."

BOP

Provisions are made to permit periodic testing of the BOP ESFAS. These tests cover the actuation from sensor input through the protection system and the actuation devices. The system test does not interfere with the protective function of the system. The testing system meets the criteria of IEEE Standard 338-1977 and of Regulatory Guide 1.22.

The frequency of testing is specified in ~~Chapter 16, Technical Specifications~~. ITS

7.3.1.1.8.1 Sensor Checks

NSSS

During reactor operation the measurement channels providing an input to the ESFAS are checked by comparing the outputs of similar channels and cross-checking with related measurements. During extended shutdown periods, such as refueling, these measurement channels, where possible, are checked and calibrated against known standards.

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BOP

During normal operation, each radiation sensor provide an input to the bistable located in the radiation monitoring local unit which can be tested and recalibrated at periodic intervals.

7.3.1.1.8.2 Trip Bistable Test

NSSS

Testing of a trip bistable, located in the PPS, is accomplished by manually varying a simulated process input signal locally on the PPS bistable control panel. This signal is increased, or decreased, until the trip setpoint is reached and the trip action is observed (see Figure 7.2-8).

Varying the simulated input signal is accomplished by means of a trip test circuit, which consists of a digital voltmeter and a test circuit that can change the magnitude of the signal supplied by the measurement channel. The trip test circuit is electrically interlocked so that it can be used in only one channel at a time (see Figure 7.2-12). A switch selects the measurement channel and a pushbutton applies the test signal. The digital voltmeter indicates the test signal value. The test circuit permits various rates of change of signal input to be used. Trip action of each of the bistable trip relays is indicated by individual lights on the front of the cabinet (see Figure 7.2-13), indicating that the contacts of these relays, which are located in the coincidence of two logic matrices, operated as required for a trip condition.

The variable setpoint test is accomplished by manually varying a simulated process input signal. Upon decreasing this input, the setpoint is verified to remain constant and the trip setpoint is within specified tolerances. By manually decreasing this input, and then depressing the setpoint reset button,

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the setpoint incremental change can be tested and verified. The tracking ability of the circuit can be tested by manually increasing the test input and observing that the setpoint tracks.

When one of the bistables of a protective channel is in the tripped condition, a channel trip exists and is annunciated on the control room annunciator panel. In this condition, an actuation would take place upon receipt of a trip signal in one of the other three like channels. The trip channel under test is, therefore, bypassed for this test, converting the ESFAS to a two-out-of-three logic which is still a coincidence of two for the particular trip parameter.

BOP

Testing of BOP ESFAS radiation monitoring system bistable is accomplished by manually varying the input signal to the actuation setpoint level on one bistable at a time and observing the actuation.

When the bistable is in a actuated tripped condition, the following conditions should exist:

a. The bistable output is deenergized.
b. The logic output signal in each actuation channel exists.
c. The ESF components are in the ESFAS actuation position.
d. Actuation is annunciated on the main control room annunciator panel.

Proper operation can be verified by the following:

a. Checking the position of each ESF component.
b. Checking the actuation annunciation.
c. Checking the ESF component status indication.

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The test is repeated for the other bistable.

7.3.1.1.8.3 Logic Matrix Tests

As described in Subsection 7.3.1.1.2.1, the BOP ESFAS logics are tested as a unit by injecting a simulated analog test signal at the upstream side of the radiation monitoring system bistable in each sensing channel and observing the actuation output signal at the logic output. At the same time, a continuous diagnostic software routine is run to check the failure of each and every circuit component functional integrity.

In order to facilitate the testing of the BOP ESFAS logic and the actuated ESF equipment, as well as the NSSS actuated equipment, the ESF equipment is categorized in the following three groups per its function ;

a. Equipment testable during normal power operation.
b. Equipment which cannot be tested during normal power operation.
c. Equipment which does not require testing.

An appropriate test group for the ESF equipment is identified on the control logic legend (See Figure 7.3-3).

The NSSS ESFAS logic matrix test is carried out to verify proper operation of the six coincidence logic matrices, located in the PPS, any one of which will initiate a system actuation for any possible coincidence of two trip condition from the signal inputs of each measurement channel. The test circuits are shown in Figures 7.2-12 and 7.2-13.

The system is interlocked so that only one logic matrix set (i.e., all AB, or all AC, etc.) can be held at a time as discussed in Subsection 7.3.1.1.4. Actuation of the rotary select switch will apply a test voltage to the test system hold coils of the double-coil matrix relays in their energized position. The |254

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deactuation of the trip relay contacts in the matrix ladder being tested caused deenergization of the primary matrix relay coils (see Figure 7.2-13).

The logic matrix to be tested is selected using the system channel trip select switch. By holding the matrix hold rotary select switch in its actuated position and rotating the system channel trip select switch through each of its positions, the trip relays in the logic matrix will be deenergized. The system channel trip select switch applies a test voltage of the opposite polarity to the bistable trip relay test coils so that the magnetic flux generated by these coils cancels that of the primary coil causing the relays to release. 254

Trip action can be observed by illumination of the trip relay indication located on the front panel and by loss of voltage to the four matrix relays, which is indicated by loss of illumination of the indicator lights connected across each matrix relay coil. During the test, the matrix relay hold lights will remain on, indicating that a test voltage has been applied to the holding coils of the matrix relays of the logic matrix under test.

The test is repeated for each actuation signal, by using the system channel trip select switch, and for all six logic matrices. This test will verify that the logic matrix relays will deenergize if the logic matrix continuity is interrupted.

7.3.1.1.8.4 Initiation Channel Tests

Each initiation circuit, in the PPS is tested individually by selecting a matrix hold rotary select switch(holding four matrix relays), selecting any trip position on the system trip select switch and selecting a matrix relay on the matrix relay trip select switch (see Figure 7.2-12). This causes the appropriate initiation circuit and corresponding cycling relay in the ESF-ARC to deenergize. Proper operation of both initiation relay coils and contacts is verified by monitoring the current through the appropriate leg of the 254

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actuation logics selective two-out-of-four circuit.

The matrix relay trip select switch is turned to the next position, reenergizing the test matrix relay and permitting the reset of the initiation circuit relays. The whole sequence is repeated for the remaining three initiation circuits from the selected matrix. The entire sequence is repeated for the remaining five matrices. Upon completion of testing, all six matrices, all 24 matrix relay contacts, and all eight initiation relays have been tested.

In addition, the remote manual switches for the initiation circuits can be tested. The indication of proper manual initiation will be the same as for automatic initiation. Only one switch is used at a time.

7.3.1.1.8.5 ESFAS Actuating Logic Test

This test verifies the proper operation of the ESFAS actuating logic circuits (refer to Figure 7.3-12). The selective two-out-of-four logic circuit, located in the ESFAS auxiliary relay cabinets, of each ESFAS train is tested in a manner identical to the RPS trip breaker system (see Subsection 7.2.1.1.9.5).

One current leg of the selective two-out-of-four logic matrix is interrupted by opening one of the current legs contacts and loss of current in that current leg is verified. Each contact in both current legs is checked in this manner.

The manual trips are checked one at a time from the ESFAS auxiliary relay cabinets. The lockout contacts are checked via the group relay test system as described below and the PPS initiation relay contacts are checked as described in the preceeding section.

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7.3.1.1.8.6 ESFAS Actuating Device Test

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Proper operation of the ESFAS group relays, in the ESFAS auxiliary relay cabinets, is verified by deenergizing the group relays one at a time via a test relay contact (see Figure 7.3-2) and noting proper operation of all actuated components in that group. The relay will automatically reenergize and return its components to the pretest condition when the test pushbutton is released.

The design of the test system is such that only one group relay may be deenergized at a time. The test switch must be positioned to the group to be tested; selection of more than one group is impossible. The test circuit is electrically locked out upon actuation of a particular test group and another test group cannot be actuated for one minute after selecting another switch position. This time delay is a "stop and think" feature to assist the operator in conducting tests.

Since this test causes the ESF components to actuate by interrupting the normal safety signal current leg to individual group relays, the propagation of a valid trip during test is not impeded and the system will proceed to full actuation by interrupting the current leg to all group relays.

For preventing from the plant shutdown by single failure of MSIS subgroup relay, some subgroup relays to actuate the MSIV, MFIV, FWP and SDV are 640
applied to the selective 2/4 logic.

7.3.1.1.8.7 Bypass Tests

NSSS

System bypasses in the PPS, as itemized in Table 7.3-1, are tested on a channel basis using internally generated test signals. This testing includes both manual initiation and automatic removal features.

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BOP

Channel bypasses in the ILS, as itemized in Table 7.3-2, can be tested using bypassed status on the MCB and annunciation. This testing includes both manual initiation and manual removal features.

7.3.1.1.8.8 Response Time Tests

Response time tests required at refueling intervals are specified in Chapter 16, Technical Specifications. These tests include the sensors for each ESFAS channel and are based on the criteria defined in Subsection 7.3.2.3.3.

7.3.1.1.9 Vital Instrument Power Supply

The vital instrument power supply for the ESFAS is described in Chapter 8.

7.3.1.1.10 Actuated Systems

The ESF systems are maintained in a standby mode during normal operations. Actuating signals generated by the ESFAS are provided to assure that the ESF systems provide the required protective actions. The following descriptions of the instrumentation and controls of the ESF systems are applicable to each ESF system. Table 7.3-3 presents the design basis events (DBE) which require specific ESF system action. Table 7.3-4 presents the monitored variables required for ESF system actuation. The variables and their ranges are shown on Table 7.3-5.

7.3.1.1.10.1 Containment Isolation System

Subsection 6.2.4 contains a description of the containment isolation system. The actuation system is composed of redundant trains A and B. The instrumentation and controls of the two trains are physically and electrically

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separate and independent such that the loss of one train will not impair the safety function.

The containment isolation system instrumentation and controls are designed for operation during all phases of plant operation. However, the system is removed from service prior to containment leak checking at refueling intervals in order to prevent undesired system actuation. The removal from service is accomplished in accordance with operating procedures.

The containment isolation system is automatically actuated by a containment isolation actuation signal. A detailed list of equipment activated by the containment isolation actuation signal is shown on Table 7.3-15, item 4.

All remote-operated (automatic or manual) containment isolation valves are provided with control switches and position lights (open/close) on the main control boards. Additionally, a close position signal of each valve inputs into the plant computer for critical function monitoring which detects unisolated containment penetrations by monitoring valve status required to close on a CIAS.

The instrumentation is provided in the main control room for the operator to know when to isolate the fluid systems.

The design of the control systems does not result in the automatic reopening of the containment isolation valves following reset of the isolation signal.

All systems that provide a path from the containment to the environs (e.g., containment purge and vent systems) have the valves closed on a CIAS signal.

7.3.1.1.10.2 Containment Spray System

Containment spray system component description and design information are

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presented in Subsection 6.2.2. Only instrumentation and controls and their operation are described in this subsection. A detailed list of equipment activated by the containment spray actuation signal (CSAS) is shown on Table 7.3-15, item 2.

a. Containment Spray Pumps

A control switch is provided for each pump on the main control board.

Each containment spray pump can be started under any of the following three conditions:

1. Automatically: A CSAS from the ESF actuation system (ESFAS) logic with proper sequencer signal will start the pump.

2. Manually: Operation of the control switch to the START position will start the pump.

3. Manually in test mode: An administrative procedure allows the manual START of the containment spray pump under the following test mode: confirm that containment isolation valve and pump discharge valve to shutdown cooling heat exchanger are closed, the isolation valve for recirculation back to the refueling water tank is open, the isolation valve between the spray addiative tank and the containment spray pump suction line is closed.

The thermocouples are provided for each motor to measure bearing temperature. Driver-end bearing temperature is monitored by the computer.

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Resistance temperature detectors (RTDs) are provided for each motor stator winding temperature. Phase B stator winding temperature is monitored by the computer.

An ammeter is provided on the main control board for each pump to measure motor current.

A flow indication in the main control room is provided to monitor the discharge flow of each pump.

A pressure gauge is provided in each pump discharge line to provide pressure indications locally.

b. Containment Spray Isolation Valve

A control switch is provided in the main control room for each valve.

Each valve can be opened automatically by the containment spray actuation signal (CSAS) from the ESFAS.

Each valve can be manually opened with its control switch in the main control room.

Limit switches on each valve provide valve position indication in the main control room.

c. Spray Additive System

The instrumentation and control is provided for the proper operation of the containment spray hydrazine additive system as follows:

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1. Control switches are provided in the main control room for spray additive pumps and spray additive isolation valves.

2. Spray additive pumps can be started automatically by a CSAS from the ESFAS.

3. Spray additive isolation valves can be opened automatically by a CSAS from the ESFAS.

4. Limit switches on each valve provide position indication in the main control room.

5. A flow indication in the main control room is provided to monitor each spray additive pump discharge flow.

6. A level indicator is provided in each spray additive tank to provide level indication locally.

d. Containment Spray System Alarm

Additional containment spray system alarms in the main control room annunciation system are provided as follows:

1. Low, low-low and empty level alarms are provided for the spray additive tank.

2. High- and low-pressure alarms are provided for spray additive tank.

3. High containment pressure alarms are provided from four redundant pressure monitors, which also initiate the CSAS.

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The containment spray system is automatically actuated by a CSAS from the ESFAS. The CSAS is removed from service prior to the containment leak test at refueling intervals in order to prevent undesired system actuation. The removal from service is accomplished in accordance with YGN 3&4 procedures.

7.3.1.1.10.3 Reactor Containment Fan Coolers

The instrumentation and controls for the reactor containment fan coolers (RCFCs) function to ensure the removal of heat from the containment under all station operating conditions as described in Subsection 6.2.2.

The following parameters have indication:

a. RCFC fan motor amperage is indicated on main control board.

b. Inlet and outlet temperature and dew point are indicated in the main control room and local control panel.

c. Inlet and outlet temperature are monitored by the computer.

d. Status of high- and low-speed operation of the RCFC fans is indicated in the main control room.

Low outlet temperature, high inlet temperature and high dew point, and fan motor trip are conditions annunciated in the main control room. Instrumentation and control shall conform to ANSI/ANS 56.6.

The RCFC units are controlled from either control switches provided on the main control room board or the remote shutdown panel. The SIAS signal will bring all operating coolers from high-speed to low-speed operation and put the nonoperating coolers in low-speed operation. The RCFC fans are interlocked to annunciate on high vibration of the fan housing.

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The RCFC units consist of redundant equipment having independent controls and instrumentation. The channels and logic circuits are physically and electrically separated to preclude the possibility that a single event will prevent operation of the RCFC units.

Means have been provided for checking the operational availability of the RCFC units separately at sensor module and control and channel basis and jointly as a complete system during operation or shutdown period.

Temperature, pressure, humidity, and radiation dose are considered in the selection of various instruments, controls, and devices for the RCFC units. These are described in detail in Section 3.11. The RCFCs are required during both normal and abnormal station operating conditions.

7.3.1.1.10.4 Control Room HVAC System

The controls and instrumentation for the control room HVAC system function to ensure the habitability of the main control room under all station operating conditions, as described in Sections 6.4 and 9.4. The design bases for the instrumentation and controls are described in Subsection 9.4.1.1. A detail list of equipment activated by the BOP ESFAS control room emergency ventilation actuation signal (CREVAS) is shown on Table 7.3-16, item 1.

7.3.1.1.10.4.1 Power Supply

Power supply for instrument, control, power, and related systems for each control room HVAC system is fed from separate ESF buses, described in Chapter 8.

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7.3.1.1.10.4.2 Initiating Circuits, Logic, and Sequencing

Various components of each redundant control room HVAC system are controlled as follows:

a. The supply and return air fans are controlled by control switches provided on the remote shutdown panels and in the main control room.

b. On any equipment malfunction alarm on the main control board, the redundant HVAC system is manually started.

c. The process radiation system detects high radiation signal in either of the two outside air intakes and takes the following simultaneous actions:

   1. alarms the high radiation levels in the affected intake in the main control room, and

   2. automatically closes the normal path of makeup air supply to the control room HVAC system and routes air to the appropriate emergency makeup air cleaning units.

d. On detection of combustion products in the control room by the smoke detection system, an alarm is annunciated in the main control room. Instrumentation and controls for the HVAC system shall conform to ANSI/ANS 59.2, and the instrumentation for emergency makeup air cleaning units is in accordance with ANSI N 509-1980 and Regulatory Guide 1.52.

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7.3.1.1.10.4.3 Bypasses add Interlocks

Refer to Subsection 7.3.1.1.3 for a discussion of bypasses and Subsection 7.3.1.1.4 for a discussion of interlocks.

7.3.1.1.10.4.4 Redundancy/Diversity

Instrumentation and controls for each control room HVAC system are completely independent of each other. For details refer to Subsections 7.3.1.1.5 and 7.3.1.1.6.

7.3.1.1.10.4.5 Separation

The channels and logic circuits are physically and electrically separated to preclude the possibility that a single event will prevent operation of control room HVAC system.

7.3.1.1.10.4.6 Testability

Instruments used for the control and logic circuitry for the control room HVAC system can be individually checked on sensor, module, channel, and system levels by simulating sensing conditions such as temperature, pressure, humidity, and combustion products to test or calibrate the sensors and observing trip or control responses. For details refer to Subsection 7.3.1.1.8.

7.3.1.1.10.4.7 Environmental Considerations

Temperature, pressure, humidity, and radiation dosage are considered in the selection of various equipment, instrumentation, and controls for the control room HVAC system. These are described in detail in Sections 3.11 and 9.4.

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7.3.1.1.10.4.8 Operational Considerations

The automatic circuitry is designed to start the emergency equipment, if the signal for its initiation is received, as described in this section. Provisions are made to allow manual control and operation of the various components of the control room HVAC system from the main control room.

7.3.1.1.10.4.9 Design-Basis Information

IEEE Standard 279 requirements are discussed in Subsection 7.3.1.

7.3.1.1.10.4.9.1 Outdoor Air Intake Radiation Protection Portion of Control Room HVAC System

a. Outdoor air intake is monitored for high radiation levels. Two redundant monitors per intake are provided for generation of the BOP ESFAS control room emergency ventilation actuation signal (CREVAS). The radioactivity levels are sensed by monitors upstream of intake isolation dampers, where the air enters the intake louvers. Upon receipt of the CREVAS, the makeup air is drawn through emergency makeup air cleaning units. The capability to manually switch to the preferred intake is provided in the main control room.

b. For operational and protective limits of the radiation monitor, see Table 11.5-1.

c. Normal operating levels are expected to be in the range of <0.5 mrem/hr.

d. The range of environmental conditions to which the radiation monitors are subjected is the same as the extreme outdoor conditions. These components are protected from direct rain impingement and are specified and qualified for the environmental conditions specified in

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Section 3.11.

e. Design provisions for earthquake, abnormal environmental conditions, and flood protection have been incorporated to retain necessary protective action.

7.3.1.1.10.4.9.2 Smoke Detection Portion of Control Room HVAC System

a. The smoke detectors are provided in main control room panels, outside air intake ducts, and supply and return ducts in the main control room. The detectors shall be powered from the non-Class 1E ac distribution panel and have a back up dc power supply. The ac power feed is monitored and annunciated upon failure.

b. The ionization level is expected to be 0 particles per cm^3. Ionization levels which are more than 200,000 particles per cm^3 are considered hazardous to control room occupancy. The ionization level which will cause protective action is approximately 100,000 particles per cm^3.

c. The electrical supply system is described in Section 8.3. The range of environmental conditions to which the ionization detectors are subjected is the same as for the main control room as listed in Section 9.4.

7.3.1.1.10.4.9.3 Toxic Gas Detection of Control Room HVAC System

There is no toxic gas detector in the main control room. For details, refer to Section 6.4.

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7.3.1.1.10.5 ECCS Equipment Room HVAC System

7.3.1.1.10.5.1 System Description

The instrumentation and controls of the ECCS equipment room HVAC system are designed to provide cooling for ECCS rooms during all the operating conditions and maintains the auxiliary building under negative pressure during accident conditions. This system is not a BOP ESFAS but performs an ESFAS support function and contains equipment and devices which are actuated upon receipt of the ESFAS. Detail description of instrumentation and control functions of this system are provided in Sections 6.5 and 9.4. The ECCS equipment room exhaust system of the ECCS equipment room HVAC system automatically actuates on SIAS.

7.3.1.1.10.5.2 Design Bases

a. The ECCS equipment room HVAC system is safety-related.

b. Loss-of-offsite power does not affect the normal functioning of instrumentation and control since they are supplied from ESF buses backed up by an emergency diesel generator.

c. The physical events accompanying a loss of coolant do not prevent correct functioning of the controls and instrumentation.

d. Instrumentation and controls of the ECCS equipment room HVAC system are designed to function following a safe shutdown earthquake.

e. The requirements of IEEE standards 279-1971, 308-1980, 323-1983, 336-1985, and 344-1975 are met by ECCS equipment room HVAC system instrumentation and controls.

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7.3.1.1.10.5.3 Power Generation Bases

The ECCS equipment room HVAC system (exhaust portion only) does not function during power generation bases.

7.3.1.1.10.5.4 Instrumentation and Controls

Instrumentation and controls for the ECCS equipment room HVAC system is provided to meet the requirement of Regulatory Guide 1.52 and per ANSI N509 for air cleaning units and ANSI/ANS 59.2 for the cubicle coolers.

7.3.1.1.10.5.5 Power Supply

Instrumentation and controls for the ECCS equipment room HVAC system is fed from the ESF buses.

7.3.1.1.10.5.6. Initiating Circuits, Logic, and Sequencing

The instrumentation and control system is provided for proper operation of the ventilation system described in Subsection 9.4.5.3.

7.3.1.1.10.5.7 Bypasses and Interlocks

Refer to Subsections 7.3.1.1.3 for a discussion of bypasses and Subsection 7.3.1.1.4 for a discussion of interlocks.

7.3.1.1.10.5.8 Redundancy

Instrumentation and controls for each ECCS equipment room HVAC system are completely independent of each other. For details refer to Subsections 7.3.1.1.5 and 7.3.1.1.6.

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7.3.1.1.10.5.9 Separation

The channels and logic circuitry are physically and electrically separated to preclude the possibility that a single event will prevent the operation of the system.

7.3.1.1.10.5.10 Testability

Instruments used for control and logic circuitry for the ECCS equipment room HVAC system can be individually checked on sensor, module, channel, and system level. Means are provided for checking operational availability of the ventilation system.

7.3.1.1.10.5.11 Environmental Considerations

Temperature, pressure, humidity, and radiation dosage are considered in the selection of various instruments and controls and devices for the ECCS equipment room HVAC system. These environmental conditions are described in Section 3.11.

7.3.1.1.10.5.12 Operational Considerations

The automatic circuitry is designed to start the ECCS equipment room HVAC system, if a signal for its initiation is received. Provisions are made to allow manual control and operation of various components of ECCS equipment room HVAC system from the control room.

7.3.1.1.10.6 Diesel-Generator Rooms HVAC System

7.3.1.1.10.6.1 System Identification

The instrumentation and controls of the diesel-generator room HVAC system are

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designed to (1) provide ventilation in the diesel-generator rooms, (2) provide ventilation in the diesel-generator oil day tank room and the diesel oil storage room, and (3) limit the maximum and minimum ambient temperature to those listed in Section 3.11.

This system is not a BOP ESFAS but performs an ESFAS support function and contains equipment and devices that are actuated upon receipt of the ESFAS. Detail description of instrumentation and control functions of this system are provided in Subsection 9.4.5.1.

7.3.1.1.10.6.2 Identification of Safety Criteria

The instrumentation and controls for this system meet the following design bases.

7.3.1.1.10.6.2.1 Safety Design Bases

a. The system prevents accumulation of diesel oil fumes in various areas of the diesel-generator rooms.

b. Loss of offsite electric power does not affect the normal functioning of controls and instrumentation since they are supplied from ESF buses backed up by an emergency diesel generator.

c. The physical events accompanying a loss-of-coolant or fuel handling accident do not prevent correct functioning of the controls and instrumentation.

d. Seismic motions resulting from earthquake ground motion, missile, wind, and flood do not impair the operation of the controls and instrumentation.

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e. The requirements of IEEE Standards 279-1971, 308-1980, 323-1974 and 344-1975 are met by the diesel-generator room HVAC system instrumentation and controls. Additionally, General Design Criteria 13, 19, 21, 22, 23, and 29 of 10 CFR 50, Appendix A, have been implemented in the design of the control system.

7.3.1.1.10.6.2.2 Power Generation Bases

a. Limit the maximum ambient temperature to the temperature listed in Sections 3.11 and 9.4.5.1 in the diesel-generator rooms and in the oil storage rooms.

b. Provide capability in the main control room to control and operate various components of the diesel-generator room ventilation system manually from the main control room.

7.3.1.1.10.6.2.3 Instrumentation and Control

Instrumentation and control for the diesel-generator room HVAC system are provided to meet the requirements of ANSI/ANS 59.2.

7.3.1.1.10.6.3 System Description

7.3.1.1.10.6.3.1 Power Supply

Ventilation equipment, instruments, and controls for the diesel-generator room HVAC system are fed from the ESF bus.

7.3.1.1.10.6.3.2 Initiating Circuits, Logic, and Sequencing

The instrument and control systems are provided for proper operation of the HVAC system described in Subsection 9.4.5.1.

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7.3.1.1.10.6.3.3 Bypasses and Interlocks

Refer to Subsection 7.3.1.1.3 for a discussion of bypasses and Subsection 7.3.1.1.4 for a discussion of interlocks.

7.3.1.1.10.6.3.4 Redundancy/Diversity

Instruments and controls are not redundant for the diesel-generator room ventilation system, since redundant diesel-generators are provided.

7.3.1.1.10.6.3.5 Separation

The channels and logic circuits of each diesel-generator room ventilation system are physically and electrically separated to preclude the possibility that a single event at one diesel-generator room ventilation system will prevent operation of the other system.

7.3.1.1.10.6.3.6 Testability

Means have been provided for checking the operational availability of complete diesel-generator ventilation control systems separately at sensor module and control channel basis and jointly as a complete system during the diesel operation or shutdown period.

7.3.1.1.10.6.3.7 Environmental Considerations

Temperature, pressure, humidity, and radiation dosage are considered in the selection of various instruments, controls, and devices for the diesel-generator room HVAC system. These are described in detail in Sections 3.11 and 9.4.

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7.3.1.1.10.6.3.8 Operational Considerations

The diesel-generator room HVAC system room ventilation is provided both during normal and abnormal station operation conditions.

7.3.1.1.10.7 Other ESF HVAC Systems

The instrumentation and controls for the ESF switchgear rooms HVAC system function to ensure maximum and minimum room ambient temperature per Section 3.11. The instrumentation and controls are provided per ANSI/ANS 59.2.

The ventilation systems are described in Subsection 9.4.5.

Class 1E instrumentation and controls are provided for ESF switchgear room HVAC system. No redundant instruments and controls are provided since each of the ventilation systems identified herein is a redundant system. The channels and logic circuits of each redundant ventilation system are physically and electrically separated to preclude the possibility that a single event at one ventilation system will prevent operation of the other system.

Means have been provided for checking the operational availability of the complete ventilation control systems identified in this subsection separately on a sensor module and control channel basis and jointly as a complete system during the ventilation system operation or shutdown period.

Temperature, pressure, humidity, and radiation dosage are considered in the selection of various instruments, controls, and devices for the ventilation system identified in this subsection.

Each ESF switchgear room HVAC system is required to operate during all station operating conditions.

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7.3.1.1.10.8 Fuel Building Emergency Exhaust System

7.3.1.1.10.8.1 System Description

The instrumentation and controls of the fuel building emergency exhaust system are designed to inhibit exfiltration of air following a fuel handling accident which releases the radioactivity.

The instrumentation and controls of the normal fuel building ventilation system function to provide a suitable atmosphere for the personnel and equipment located within the fuel building.

The fuel building emergency exhaust system is described in detail in Subsection 9.4.2.

A detailed list of equipment activated by the fuel building emergency ventilation actuation signal (FBEVAS) is shown on Table 7.3-16, item 3.

7.3.1.1.10.8.2 Design Bases

a. The fuel building emergency exhaust system is safety-related and will filter the radioactive airborne fission products.

b. Loss of offsite power does not affect the normal functioning of instrumentation and control since they are supplied from the vital buses, which are fed from an uninterruptible power supply and backed up by battery.

c. The physical events accompanying a loss-of-coolant or fuel handling accident do not prevent correct functioning of the instrumentation and controls.

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d. Instrumentation and controls of the fuel building emergency exhaust system are designed to function following a safe shutdown earthquake.

e. The requirements of IEEE standards 279-1971, 308-1980, 323-1974, 336-1985, and 344-1975 are met by fuel building emergency exhaust system instrumentation and controls.

7.3.1.1.10.8.3 Power Generation Bases

The fuel building emergency exhaust system functions following a fuel handling accident to inhibit exfiltration of air to prevent release of radioactivity.

7.3.1.1.10.8.4 Instrumentation and Controls

Instrumentation and controls for the exhaust and filtration portions of the system will be provided to meet the requirement of Regulatory Guide 1.52 and per ANSI N509 (1980).

7.3.1.1.10.8.5 Power Supply

Instrumentation and controls for fuel building emergency exhaust system will be is fed from the vital buses power supply system, which is backed up by battery.

7.3.1.1.10.8.6 Initiating Circuits, Logic, and Sequencing

The instrumentation and control system will be provided for proper operation of the ventilation system described in Subsetion 9.4.2.

Two redundant radioactivity detectors in the spent fuel pool area provide radioactivity signals that produce two redundant signals for generation of the BOP ESFAS fuel building emergency ventilation actuation signal (FBEVAS). The

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emergency exhaust system is on standby for an automatic start following receipt of FBEVAS signal.

The radioactivity signals and actuation bistable outputs are furnished to the plant computer system and plant annunciator system through isolation circuitry.

The control logic for the fuel building emergency ventilation actuation system is shown on Figure 7.3-5.

7.3.1.1.10.8.7 Bypasses and Interlocks

Refer to Subsection 7.3.1.1.3 for a discussion of bypasses and Subsection 7.3.1.1.4 for a discussion of interlocks.

7.3.1.1.10.8.8 Redundancy

Instrumentation and controls for each fuel building emergency exhaust system are completely independent of each other.

7.3.1.1.10.8.9 Separation

The channels and logic circuitry are physically and electrically separated to preclude the possibility that a single event will prevent the operation of the system.

7.3.1.1.10.8.10 Testability

Instruments used for control and logic circuitry for fuel building emergency exhaust system can be individually checked on sensor, module, channel and system level. Means are provided for checking operational availability of ventilation system.

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7.3.1.1.10.8.11 Environmental Considerations

Tempearture, pressure, humidity, and radiation dosage are considered in the selection of various instruments and controls and devices for the fuel building emergency exhaust system. These environmental conditions are described in Section 3.11.

7.3.1.1.10.8.12 Operational Considerations

The automatic circuitry is designed to start the fuel building emergency exhaust system if a signal for its initiation is received. Provisions are made to allow manual control and operation of various components of the fuel building emergency exhaust system from the control room.

7.3.1.1.10.9 Auxiliary Feedwater System

The auxiliary feedwater system (AFWS) is discussed in Subsection 10.4.9.

The AFWS is actuated by an AFAS. The instrumentation and controls of Train A are physically and electrically separate and independent of the instrumentation and controls of Train B. Thus, if a single failure prevents actuation of one train, the other train will still receive an actuation signal.

The AFAS and diverse protection system (DPS) signal starts the pumps in either the manual or automatic mode and will cycle the motor-operated valves whereas the air-operated valves (AOV's) receive a latching signal and modulate based on SG level signal.

The anxiliary feedwater system automatic initiation and flow indication is provided in accordance with NUREG-0718, action item II.E.1.2.

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A detailed list of equipment activated by the auxiliary feedwater actuation signal is shown on Table 7.3-15, item 6.

a. Auxiliary Feedwater Pumps

Each pump is provided with a control switch each in the main control room and on the remote shutdown panel.

A pump is automatically stopped by the low pump suction pressure.

Alarms are provided in the main control room for pump suction and low discharge pressure.

Three chromel-constantan thermocouples are provided for each pump to measure bearing temperatures. Drive-end temperature is monitored by the computer. 100 Ω platinum RTDs are provided for each pump to measure pump motor stator temperature. Hottest temperature is monitored by the plant computer.

An ammeter is provided in the main control room for the motor-operated pump to measure motor current.

A pressure gauge and transmitters indicate pump discharge and suction pressure locally and remotely. A pressure switch is provided on each pump suction line to trip the pump and energize a low suction pressure alarm.

A recirculation line is provided for each pump to ensure minimum flow through the pump.

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b. Auxiliary Feedwater Pumps Suction Valves

Normal suction to the auxiliary feedwater pumps is from the condensate storage tank through normally open manual valves. A backup source is available from the raw water reservoir through two normally closed manual valves in series for each pump.

c. Auxiliary Feedwater Isolation

Each valve is provided with a control switch in the main control room and on remote on shutdown panel.

Limit switches on each valve are used to operate lights at the main control board indicating valve position.

d. Auxiliary Feedwater Flow Control

A flow element, indicators, and transmitters are provided in each of auxiliary feedwater supply lines. Each transmitter sends a flow signal to an indicator on the main control board and the remote shutdown panel.

The auxiliary feedwater flow to the two steam generators is normally controlled via the manual/automatic (M/A) level control stations mounted in the main control room and remote shutdown panel. Each manual/automatic level control station electrically transmits a flow signal to an electric-to-pneumatic (E/P) converter. The pneumatic output flow signal is transmitted through a permissive three-way solenoid valve (which, when deenergized, drives the valve open) to the flow control valves. Flow is controlled automatically via an SG level controller provided at the M/A station.

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The control of the flow control valves from the remote shutdown panel is accomplished by duplicate controls to the MCB.

A failure in the level control system for the control valve will cause the valve to fail open. The failure analysis is provided in Table 7.2-5.

e. Valve Back-Leakage Detection Thermocouples

In order to detect leakage from the main feedwater line back into the auxiliary feedwater line, thermocouples are provided in the auxiliary feedwater line near the feedwater junction and annunciation of high temperature of the thermocouples is provided in the MCB for operator action. This alerts the operator to the possibility of steam binding in the auxiliary feedwater pumps.

f. Diverse Sources of Motive Power

Diverse sources of motive power are provided for the auxiliary feedwater pumps, valve operators, instrumentation, and controls as discussed below.

The electrical supply for the motor-operated valves and their controlling instrumentation is fed from the redundant ESF buses. A particular valve's bus assignment is the one associated with its respective pump. Therefore, the pair of valves associated with each steam generator are powered from redundant ESF buses.

The air-operated valves are supplied from the instrument air system with a safety-related backup nitrogen system. The instrument air system is described in Subsection 9.3.1. The control instrumentation is supplied from the essential instrument power buses as described in

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Subsection 8.3.1. A particular valve's instrument bus assignment have the same train designated as the ESF bus associated with the corresponding motor-operated valve and pump.

Therefore, the pair of valves associated with each steam generator are powered from redundant instrument power buses.

7.3.1.1.10.10 Safety Injection System

Refer to Section 6.3 for a description of the safety injection system (SIS). The SIS is actuated by an SIAS.

The actuation system is composed of redundant Trains A and B. The instrumentation and controls of Train A are physically and electrically separate and independent of instrumentation and controls in Train B. Since each train is a 100% capacity system, the SIS can sustain the loss of an entire train and still provide its required protective action. The SIS instrumentation and controls are designed to operate under all plant conditions.

The low pressurizer pressure setpoint can be decreased as described in Subsection 7.3.2 to avoid inadvertent operation during startup and shutdown. As pressurized pressure increases, the setpoint will follow up to its normal value. The SIAS is removed from service during containment leak checking at refueling intervals to prevent undesired system operation. The removal from service is accomplished in accordance with YGN 3&4 procedures. A detailed list of equipment activated by the SIAS is shown on Table 7.3-15, item 1.

7.3.1.1.10.11 Essential Service Water System

There are two 100% capacity essential service water pumps associated with each train. The two trains in each unit are powered from independent ESF buses.

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A control switch is provided for each pump in the main control room and on the remote shutdown panel.

The pump can be started manually provided that the pump discharge isolation valve of the corresponding safety train is 15% open. The pump can be started automatically by a safety injection signal provided that the suction valve is open. The pump can be stopped manually provided ESFAS actuation relays are reset. Protective relays trip the motor breaker open on overcurrent conditions. The standby pump automatically starts when low discharge pressure is detected at the operating pump.

A pressure gauge and transmitter are provided in each pump discharge line for pressure indication locally and on the main control board.

An ammeter is provided in the main control room and on the remote shutdown panel to display motor current.

Motor stator winding temperatures for each pump is sensed and monitored by the plant monitoring system.

A control switch is provided in the main control room for each pump discharge valve. Limit switches on each valve provide valve position indication in the main control room.

The water temperature of each component cooling water (CCW) heat exchanger discharge is indicated locally, and the water temperature of common head line is recorded in the main control room.

Refer to Subsections 9.2.1.2 and 7.3.1.1 for additional information.

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7.3.1.1.10.12 Component Cooling Water System

In the event of a safety injection signal, one component cooling water (CCW) pump in each train starts automatically to provide cooling water for RCFCs, the spent fuel pool and other essential loads inside the containment, and auxiliary building.

Upon a recirculation actuation signal, the second CCW pump is each train starts automatically to provide additional cooling water to the SDS heat exchangers.

During loss-of-offsite power (LOOP) or LOCA with LOOP, the CCW pumps are sequenced to station emergency diesel generators.

On a safety injection actuation signal, valve actuation required to establish the proper system configuration are shown in Table 7.3-15, item 1.

Motor stator winding temperature and bearing temperature are sensed and monitored by the plant monitoring system.

Refer to Subsections 9.2.2.2 and 7.3.1.1 for additional information.

7.3.1.1.10.13 Main Steam Isolation System

Refer to Section 10.3 for a description of the main steam isolation system. Refer to Subsecton 10.4.7, for a description of the feedwater isolation system. Refer to Subsection 10.4.8 for a description of the blowdown isolation system.

The actuation system is composed of redundant Trains A and B. The instrumentation and controls of the valves in Train A are physically and electrically separate and independent of the instrumentation and control of the valves of

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Train B. The separation and independence are such that a failure of one train will not impair the protective action.

The main steam isolation valves (MSIVs), main steam isolation bypass valves (MSIBVs), and main feedwater isolation valves (MFIVs) are actuated by an MSIS. The isolation valves for the blowdown lines are actuated by AFAS, CIAS, MSIS and SG blowdown radiation high signal. These valves effectively isolate the steam generators from the rest of the main steam and feedwater systems.

A variable steam generator pressure setpoint is implemented to allow controlled pressure reductions, such as shutdown depressurization, without initiating an MSIS. The pressure setpoint will track the pressure up until it reaches its normal setpoint value. A detailed list of equipment activated by the MSIS is shown on Table 7.3-15, item 5.

7.3.1.1.10.14 Emergency Diesel-Generator

This system is described in Chapter 8.

7.3.1.1.10.15 Emergency Diesel-Generator Fuel Storage and Transfer System.

This system is described in Section 7.4 and Subsection 9.5.4.

7.3.1.1.10.16 Class 1E DC system

This system is described in Chapter 8.

7.3.1.1.10.17 Class 1E Auxiliary Power System

This system is described in Chapter 8.

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7.3.1.1.10.18 Containment Purge Isolation System

7.3.1.1.10.18.1 System Description

The instrumentation and controls of the containment purge isolation system are designed to inhibit exfiltration of air which could release containment radioactivity.

The containment purge system including containment isolation valves and interconnecting piping is described in detail in Subsection 9.4.6.2.

A detailed list of equipment activated by the CPIAS is shown on Table 7.3-16, item 2.

7.3.1.1.10.18.2 Design Bases

a. The isolation valves for the contaiment purge system and the instrumentation and controls for the CPIAS are safety-related. The containment isolation valves close on a containment purge isolation actuation signal or containment isolation actuation signal. The remainder of the containment purge system is not safety-related.

b. Loss-of-offsite power does not affect the normal functioning of the instrumentation and controls that actuate the CPIAS since they are supplied from the vital buses which are fed from an uninterruptible power supply and backed up by batteries.

c. The physical events accompanying design-basis accidents do not prevent correct functioning of the instrumentation and controls that actuate the CPIAS.

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d. The instrumentation and controls for the CPIAS are designed to function during and following a safe shutdown earthquake.

e. The requirement of IEEE Standards 603-1980, 279-1971, 308-1980, 323-1974, 336-1985, and 344-1975 are met by the containment purge isolation actuation instrumentation and controls design.

7.3.1.1.10.18.3 Power Generation Design Bases

The containment purge isolation system functions following the design-basis accidents to inhibit exfiltration of air to prevent release of radioactivity. Therefore, there is no power generation design basis.

7.3.1.1.10.18.4 Instrumentation and Controls

Instrumentation and controls for the contaiment purge isolation system is provided to meet the requirement of ANSI/ANS 56.2 and ANSI/ANS 51.1.

7.3.1.1.10.18.5 Power Supply

Instrumentation and controls for the containment purge isolation actuation system are fed from the vital buses which are fed from an uninterruptible power supply and backed up by batteries.

7.3.1.1.10.18.6 Initiating Circuits, Logic, and Sequencing

The instrumentation and control system is provided for proper operation of the containment purge system described in Subsection 9.4.6.2.

Four separate, independent radioactivity monitors two for monitoring the refueling machine area two for monitoring the containment upper operating area provide, upon detection of high radiation levels, signals to bistable units

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which produce redundant BOP ESFAS containment purge isolation actuation signals (CPIAS) to the automatic actuation logic.

The containment purge isolation actuation system utilizes enhanced double one-out-of-two logic shown on Figure 7.3-6 to actuate containment purge isolation when required.

7.3.1.1.10.18.7 Bypasses and Interlocks

Refer to Subsection 7.3.1.1.3 for a discussion of bypasses and Subsection 7.3.1.1.4 for a discussion of interlocks.

7.3.1.1.10.18.8 Redundancy

Two redundant radiation sensors are provided to develop an enhanced one-out-of two logic for each train as shown in Figure 7.3-6.

7.3.1.1.10.18.9 Separation

The channels and logic circuitry are physically and electrically separated to preclude the possibility that a single event will prevent the operation of the system.

7.3.1.1.10.18.10 Testability

Instruments used for control and logic circuitry for the containment purge isolation system can be individually checked at the sensor, module, channel, and system level. Means are provided for checking the operational availability of the actuation logic.

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7.3.1.1.10.18.11 Environmental Considerations

The CPIAS system functions during normal, shutdown, and postaccident conditions. Temperature, pressure, humidity, and radiation dosage are considered in the selection of various instruments, controls and devices for the containment purge isolation system. These environmental conditions are described in Section 3.11.

7.3.1.1.10.18.12 Operational Considerations

The automatic circuitry is designed to close the containment isolation valves on the purge system if a signal for its initiation is received. Provisions are made to allow manual control and operation of various components of the containment purge isolation system from the control room as well as manual actuation of the CPIAS itself.

7.3.1.1.10.19 Recirculation Actuation Signal

An RAS (recirculation actuation signal) is generated when the level in the RWT falls below a predetermined level. When an RAS is received the LPSI pumps are stopped and the HPSI and CSS pumps shift suction to the containment recirculation sump.

An RAS may be removed from the LPSI pumps to allow them to be used for the Shutdown Cooling System in accordance with operating procedures.

A detailed list of equipment activated by the RAS is shown on Table 7.3-15, item 3.

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7.3.1.2 Design Bases

NSSS

The design bases of the ESF systems are discussed in Chapter 6. The ESFAS is designed to provide initiating signals for ESF components which require automatic actuation following the design bases events shown on Table 7.3-3.

The systems are designed in compliance with the applicable criteria of the NRC, "General Design Criteria for Nuclear Power Plants," Appendix A, 10 CFR 50. System testing conforms to the requirements of IEEE 338-1977, "Standard Criteria for Periodic Testing of Nuclear Power Generating Station Protection Systems," and Regulatory Guide 1.22, "Periodic Testing of Protection System Actuation Functions."

Specific design criteria for the ESFAS are detailed in IEEE 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Section 3. The following is a discussion of the specific items in IEEE 279-1971 and their implementation.

The plant process conditions requiring actuation of the ESFAS are listed on Table 7.3-3, which also shows which system will actuate for each event. The monitored variables required for ESF system protective action are listed on Table 7.3-4, which also shows which signals are generated by the variable. The number and location of the sensors required to monitor the variables are listed in Table 7.3-6. The normal operating ranges, actuation setpoints, the nominal full power value, and the margin between the last two are listed on Table 7.3-7. The ranges of the ESFAS variables are listed on Table 7.3-5.

The ESFAS is designed with consideration given to unusual events that could degrade system performance. System components are qualified for the environmental conditions discussed in Section 3.11 and the seismic conditions dis-

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cussed in Section 3.10 (Reference 1). A single failure within the system will not prevent proper protective action at the system level. The single failure criterion is discussed in Subsection 7.3.2.3.2.

The ESFAS minimum response times are specified in Chapter 16, Technical Specifications. The total ranges of ESFAS variables are provided in Table 7.3-5.

The uncertainties and response times of ESF systems and components are provided in ~~the Chapter 16, Technical Specifications~~. Subsection 7.3

BOP

The design bases for BOP ESFAS are as follows.

The BOP ESFAS is designed to provide initiating signals for components that require automatic actuation following a design-basis event (DBE).

The systems are designed on the following bases to ensure adequate performance of their protective functions:

a. The system is designed in compliance with the applicable criteria of Appendix A of 10 CFR 50.

b. System testing conforms to the requirements of IEEE Standard 338-1977 and Regulatory Guide 1.22.

c. IEEE 279-1971 establishes specific protection system design bases. The following paragraphs describe how the design bases listed in Section 3 of IEEE 279-1971 are implemented.

   1. The following plant process conditions require protective action:

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a) Fuel handling accident
b) Fire or smoke in the plant vicinity
c) Maintainance of main control room habitability

2. The system is designed to monitor the following parameters in order to provide protective actions:

a) Containment radiation/airborne activity
b) Fuel building radiation/airborne activity
c) Control room air intake activity
d) Control room air intake smoke

3. The number and location of the sensors required to monitor the above variables are listed in Table 7.3-8.

4. The normal operation limits for each variable are provided in Table 7.3-9.

5. The margin between the operation limits and actuation setpoints are provided in Table 7.3-9.

6. The actuation setpoints are provided in Table 7.3-9.

7. System components are qualified for the environmental conditions discussed in Section 3.11. In addition, the system is capable of performing its intended functions under the most degraded conditions of the electric support system as discussed in Section 8.3.

8. The BOP one-out-of-two engineered safety features actuation system is designed with consideration given to unusual events that could degrade system performance so that

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a) a loss of power to the measurement channels causes system actuation ;

b) any single failure within the system shall not prevent proper protective action at the system level (the single failure criterion is discussed in Subsection 7.3.2.3.2) ;

c) the environmental conditions under which the ESFAS shall be capable of performing its intended function are described in Section 3.11.

d) the seismic conditions described in Section 3.10 shall not prevent the ESFAS from performing its intended function.

9. The minimum performance requiremnts of the one-out-of-two ESFAS are the ESFAS system response times provided in Table 7.3-16. The total ESFAS response times represent the sum of the sensor response time plus the one-out-of-two ESFAS response time.

The ESFAS minimum response times and the accuracies of the ESFAS measurement channels are specified in Table 7.3-17. The total range of ESFAS variables 322
are provided in Table 7.3-7.

The overall accuracies and response times of the ESFAS and the ESF systems are shown on Table 7.3-14.

7.3.1.3 Final System Drawings

The NSSS typical functional control logic diagrams are shown in the figures following this section. Final electrical wiring diagrams, control and instrumentation diagram, and the control logic diagram for those system under the BOP scope is listed in Section 1.7.

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7.3.1.3 Final System Drawings

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The RAS has added manual actuation which gives the operator greater operational flexibility.

The MSIS logic (refer to Figure 7.3-1) has been added the high steam-generator water level and high containment pressure. This protects downstream equipment from two-phase flow and reduces the amount the reactor coolant system could be cooled due to excessive feedwater flow.

MCBDs related to the ESFAS are provided in Section 7.1. A list of applicable drawings and diagrams is provided in Section 1.7.

7.3.1.4 ESFAS Supporting Systems

The systems which is not described in this section required to support the ESFAS are discussed in Section 7.4. The electrical power distribution is discussed in Section 8.3.

7.3.2 Analysis

7.3.2.1 Introduction

NSSS

The ESFAS is designed to provide protection against the design-basis events listed on Table 7.3-3. The ESF systems that are actuated are discussed in Chapter 6, along with their design bases and evaluations.

The signals which will cause each ESFAS signal are listed in Table 7.3-4; the bases are discussed in Subsection 7.3.1.2; the actuation setpoints are given on Table 7.3-7. Most ESFAS signals are single parameter, fixed setpoint actuations. The following ESFAS signals do not fall into this category:

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a. Low pressurizer pressure - can be decreased to 400 psi (28 kg/cm^2) below the existing pressurizer pressure by the operator.

b. Low steam generator pressure - can be decreased to 200 psi (14 kg/cm^2) below the existing steam generator pressure by the operator.

Additionally, several ESFAS signals can be actuated by more than one parameter. That is, different parameters can cause the same ESFAS signal. The ESFAS signals which fall into this category are as follows:

a. SIAS by either low pressurizer pressure or high containment pressure;

b. CIAS by receiving the SIAS for that channel so that it actuates on low pressurizer pressure or high containment pressure;

c. MSIS by high steam generator water level in either steam generator, low steam generator pressure in either steam generator, or high containment pressure.

One ESFAS signal is, essentially, a multi-parameter actuation. An AFAS is generated on low steam generator water level unless that steam generator has been identified as being ruptured. A steam generator is identified as being ruptured when its pressure is some differential value below the pressure of the other steam generator, coincident with its own low level signal and with the other steam generator being identified as not ruptured.

Each ESFAS signal setpoint is selected to be consistent with the function of the respective ESF system requirements. The setpoints are selected to provide ESF actuation in sufficient time to provide the necessary actions to mitigate the consequences of the design basis events which caused the ESFAS signal.

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The adequacy of all ESFAS trip setpoints is verified through an analysis of the pertinent system transients reported in Chapter 15. These analyses utilize an analysis setpoint (assumed trip initiation point) and system delay times associated with the respective trip functions. The analysis setpoint along with the instrument uncertainties provides the basis for the calculation of the final equipment setpoints to be reported in the Technical Specifications. Limiting trip delay times are given in Chapter 15. The manner by which these delay times and uncertainties will be verified is discussed in Subsection 7.2.1.2.

7.3.2.1.1 Design-Basis Events

The design-basis event (DBE) conditions for which the system will take action are those unplanned events under conditions that may occur once during the life of several nuclear generating stations, and certain combinations of unplanned events and degraded systems that are never expected to occur during the life of all nuclear power plants. The consequences of these events should be limited by the ESF systems. The ESF systems have a major responsibility to mitigate the consequences of the events listed below. This includes minimizing fuel damage and subsequent release of fission products or other related effects. The following limiting fault conditions actuate the ESFAS:

a. RCS pipe rupture

b. Single CEA ejection

c. Steam system pipe rupture

d. Depressurization due to inadvertent actuation of primary or secondary safety valves at 100% power

e. Feedwater system pipe rupture

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The ESFAS will also act to mitigate the consequences of incidents of moderate frequency (IMF) and infrequent incidents as follows:

a. Excess heat removal due to secondary system malfunctions

b. Inadvertent pressurization or depressurization of the RCS

c. Change in normal heat transfer capability between steam and reactor coolant systems including

   1. inadequate feedwater and
   2. loss of external load

d. Steam generator tube rupture

7.3.2.2 Actuation Bases

The ESFAS consists of six signals based on five parameters. Each ESFAS signal has manual actuation switches on the main control board or at the ESFAS auxiliary relay cabinets.

7.3.2.2.1 Safety Injection Actuation Signal (SIAS)

Input

Input to the SIAS is by pressurizer pressure, containment pressure, or manual pushbuttons. The pressure signals are shared with the RPS.

Function

The SIAS actuates the components necessary to inject borated water into the reactor coolant system and actuates components for emergency cooling and

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emergency diesel generators, to ensure backup supply of power to emergency and supporting system components in case of loss of offsite power (LOOP). SIAS is also initiated by a loss of power to two channels.

7.3.2.2.2 Containment Spray Actuation Signal (CSAS)

Input

Input to the CSAS is by containment pressure signals or manual pushbuttons.

Function

The CSAS actuates the containment spray system and emergency diesel generator, to ensure backup supply of power to emergency and supporting system components in case of loop CSAS is also initiated by a loss of power to two channels.

7.3.2.2.3 Recirculation Actuation Signal (RAS)

Input

Input to the RAS is by refueling water tank (RWT) level or manual pushbuttons.

Function

The RAS is provided to actuate the recirculation mode of operation of the emergency core cooling system. RAS is also initiated by a loss of power to two channels.

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7.3.2.2.4 Containment Isolation Actuation Signal (CIAS)

Input

Input to the CIAS is by pressurizer pressure, containment pressure, or manual pushbuttons. The pressurizer and containment pressure signals are provided via the SIAS.

Function

The CIAS actuates the isolation of lines penetrating the containment. CIAS is also initiated by a loss of power to two channels.

7.3.2.2.5 Main Steam Isolation Signal (MSIS)

Input

Input to the MSIS is by pressure from each steam generator, containment pressure, level from each steam generator, or manual pushbuttons. The pressure and level signals are shared with the RPS.

Function

The MSIS is provided to actuate the isolation of each steam generator by closing the main steam isolation valves (MSIVs) and the main feedwater isolations valves (MFIVs). MSIS is also initiated by a loss of power to two channels.

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7.3.2.2.6 Auxiliary Feedwater Actuation Signal (AFAS)

Input

Input to the AFAS is by level and pressure from each steam generator with "not ruptured" calculated signal or manual switches. The level signal is shared with the RPS.

Function

The AFAS actuates auxiliary feedwater on low water level to the intact steam generator(s). AFAS is also initiated by a loss of power to two channels. The AFAS is based on the following conditions: where low steam-generator water level trip exists, its pressure is greater than the other steam generators' pressure by a predetermined value or the other steam generator is identified as not ruptured.

Actuation circuit AFAS 1 pertains to steam generator 1 and AFAS 2 actuation circuit pertains to steam generator 2.

The AFAS actuates the emergency diesel generator to ensure a back-up supply of power to emergency and supporting system components in case of loop.

7.3.2.2.7 Containment Purge Isolation Actuation Signal (CPIAS)

Input

Input to the CPIAS is by containment upper operating area and refueling machine bridge area radiation or manual actuation switches.

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Function

The CPIAS isolates and closes the contain purge lines and stops the containment purge fans.

7.3.2.2.8 Control Room Emergency Ventilation Actuation Signal (CREVAS)

Input

Input to the CREVAS is by control room air intake airborne radiation or manual actuation switches.

Function

The CREVAS isolates the normal control room ventilation system, starts the emergency ventilation system, and maintains the positive pressure in the control complex envelope.

7.3.2.2.9 Fuel Building Emergency Ventilation Actuation Siganl (FBEVAS)

Input

Input to the FBEVAC is by fuel building spent fuel pool area radiation or manual actuation switches.

Function

The FBEVAS isolates the normal HVAC and starts the emergency ventilation system.

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7.3.2.3 Design

7.3.2.3.1 General Design Criteria

Appendix A, 10 CFR 50, "General Design Criteria for Nuclear Power Plants," established minimum requirements for the principal design criteria for water-cooled nuclear power plants. This section describes the requirements that are applicable to the ESFAS. Most references will be to Section 3.1 where the criteria are first addressed. Subsection 7.2.2.3.1 will be referenced if other comments from the RPS are applicable.

Criterion 1 - Quality Standards and Records:
Refer to Subsection 3.1.2.1 for compliance.

Criterion 2 - Design Bases for Protection Against Natural Phenomena:
Refer to Subsection 3.1.2.2 for compliance.

Criterion 3 - Fire Protection:
Refer to Subsection 3.1.2.3 for compliance.

Criterion 4 - Environmental and Missile Design Bases:
Refer to Subsection 3.1.2.4 for compliance.

Criterion 13 - Instrumentation and Control:
Refer to Subsection 3.1.2.9 for compliance. Variables monitored are those which affect ESF systems.

Criterion 16 - Containment Design:
Refer to Subsection 3.1.2.12.

Criterion 20 - Protective System Functions:
Refer to Subsection 3.1.2.16 for compliance. ESF action will

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be automatically initiated upon sensing the presence of accident conditions, except for the combustible gas control system. ESF action will be manually initiated for this system since it is not required immediately after a DBA. Sufficient information is provided to allow the operator to make a timely decision as to system operating requirements.

Criterion 21 - Protection System Reliability and Testability:
Refer to Subsection 3.1.2.17 for compliance.

Criterion 22 - Protection System Independence:
Refer to Subsection 3.1.2.18 for compliance. Independence is ensured through the redundance and diversity described in Subsections 7.3.1.1.5 and 7.3.1.1.6. Two independent sensor channels are provided for the one-out-of-two ESFAS inputs. Two independent output paths are provided for the one-out-of-two ESFAS outputs. From the PPS cabinet the signals are sent to two ESFAS auxiliary relay cabinets or from the radiation monitoring system local units to ILS cabinets. In each cabinet is the selective actuation logic for each train. There is no interconnection between the two redundant cabinets or the trains they actuate so that train A is completely independent of train B.

Criterion 23 - Protection System Failure Modes:
Refer to Subsection 3.1.1.2.19 for compliance.

Criterion 24 - Separation of Protection and Control Systems:
Refer to Subsection 3.1.2.20 for compliance.

Criteria 34, 35, 37, 38, 40, 41, 43, 44 and 46:

Refer to Section 3.1 for compliance.

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The ESFAS provides the actuation which meets the requirements of IEEE 279-1971 and IEEE 338-1977. The single failure criterion is met for all ESFAS. The ESFAS is fully testable. Those components which cannot be tested during power operations are tested when the plant is shut down.

7.3.2.3.2 Equipment Design Criteria

Many of the design criteria for protection systems are discussed in Subsection 7.1.2. IEEE 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," establishes minimum requirements for safety-related functional performance and reliability of the ESFAS. This section describes how the requirements of Section 4 of IEEE 279-1971 are satisfied. The following heading numbers correspond to the section numbers of IEEE 279-1971:

4.1 General Functional Requirements

The ESFAS is designed to actuate the appropriate ESF systems, when required, to mitigate the consequences of the specified design-basis events. Instrument performance characteristics, response times, and accuracies are selected for compatibility with, and adequacy for, the particular function. Actuation setpoints are established by analysis of the RCS parameters, steam generator parameters, and containment pressure. Factors such as instrument inaccuracies, bistable trip delay times, valve travel times, and pump starting times are considered in establishing the margin between the actuation setpoints and the safety limits. In addition, the possible loss of ac power and the time required to start standby power and to sequence loads must also be considered. The time response of the sensors or protection systems are evaluated for abnormal conditions. Since all uncertainty factors are considered as cumulative for the derivation of these times, the actual response time may be more rapid. However, even at the maximum times, the system provides conservative protection.

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4.2 Single Failure Criterion

NSSS

The ESFAS is designed so that any single failure within the system will not prevent proper protective action at the system level. No single failure will defeat more than one of the four protective channels associated with any one trip function.
The effects of single faults in the RPS are discussed in Subsection 7.2.2.3.2. A similar analysis is applicable to that portion of the ESFAS located in the PPS cabinet. The initiating signal from the PPS goes to two separate ESFAS auxiliary relay cabinets. Each cabinet contains the actuation circuitry and group relays for each train; therefore, a failure in one cabinet cannot affect the circuitry and actuated equipment of the other cabinet.

Single faults of the initiation relay or actuation relay buses have no effect, as a selective two-out-of-four logic is required for actuation.

Single faults of the actuation (or control) circuitry will cause, at worst, only a failure of a component, group of components, or actuation of a system within one of the two redundant actuation trains; actuation of the remaining redundant train components is sufficient for the protective action.

BOP

The BOP ESFAS is designed so that any single failure within the protection system shall not prevent proper protective action at the system level when required. No single failure will defeat more than one of the two protective channels associated with any one trip function.

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Although no single failure will defeat more than one of the two protective channels, a single failure may cause spurious actuation. However, this spurious actuation is allowable since it does not create plant conditions requiring protective action nor does it interfere with normal reactor operations.

A complete analysis of single failures for the one-out-of-two is presented in Tables 7.3-10 through 7.3-13. The worst-case single failure is the failure of relay in the Interposing Logic System module to deenergize. This condition causes loss of one of the two redundant sets of associated ESF equipment.

4.3 Quality Control of Components and Modules

The system is designed in accordance with the Quality Assurance Program.

4.4 Equipment Qualification

The ESFAS equipment is qualified in accordance with the methodology discussed in Sections 3.10 and 3.11.

4.5 Channel Integrity

Type testing of components, separation of sensors and channels, and qualification of cabling are utilized to ensure that the channels will maintain their functional capability required under applicable extremes of environment, power supplied, malfunction, and DBE conditions. Loss or damage of any one path will not prevent the protective action of the ESFAS. Sensors are piped using materials of comparable quality to the systems to which they are attached so that, in the unlikely event of blockage or failure of any one connection, protective action is not prevented. The process sensors located in the containment building are

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specified and rated for the intended service. Components which must operate during or after DBEs are rated for the expected postevent environment. Results of type tests are used to verify these ratings.

4.6 Channel Independence

NSSS

The location of the sensors, for the ESFAS, and the points at which the sensing lines are connected to the process loop have been selected to provide physical separation of the channels within the system, thereby precluding a situation in which a single event could remove or negate a protective action. The routing of cables from protection system transmitters is arranged so that the cables are separated from each other, and from power cabling, to minimize the likelihood of common event failures. This includes separation of the containment penetration areas.

The initiation paths are located in four bays of the PPS cabinet and the actuation devices are fed from the two ESFAS auxiliary relay cabinets. Mechanical and thermal barriers within these cabinets minimize the possibility of a common mode failure. Common mode failure is addressed in Topical Report CENPD-148, "Review of Reactor Shutdown System (PPS Design) for Common Mode Failure Susceptibility" (Reference 3).

The output from these redundant channels are isolated from each other so that loss of a channel does not cause loss of the system. The signals from the ESFAS which supply the PMS are isolated at the PMS input. The ESFAS annunciators are isolated as necessary to ensure the ESFAS maintains its channel independence.

The criteria for separation and physical independence of channels are based on the need for decoupling the effects of DBE consequences and

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power supply transients, and for reducing the likelihood of channel interaction during testing or in the event of a channel malfunction.

BOP

The channel independence is described in Subsection 7.3.1.1.5.

4.7 Control and Protection System Interaction

4.7.1 Classification of Equipment

No portion of the ESFAS is used for both protective and control functions.

4.7.2 Isolation Devices

Signals sent from the ESFAS to the plant monitoring system (PMS) are isolated at the plant data acquisition system (PDAS) and annunciators are isolated at the plant annunciation system such that a failure in these areas will not affect the protective action of the ESFAS.

4.7.3 Single Random Failure

This criterion is not applicable since there are no channels used for both control and protection. Therefore, a single random failure can only occur in either a control or a protection channel.

4.7.4 Multiple Failures Resulting from a Credible Single Event

This cannot exist because control and protection channels have nothing in common.

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4.8 Derivation of Signal Inputs

NSSS

Insofar as possible, inputs are derived from signals that are direct measurements of the desired variable. Directly measured variables include pressurizer, containment, and steam generator pressures. The steam generator and refueling water tank levels are derived from differential pressure signals. The differential between the steam generator pressures, for the AFAS, is a calculated value.

BOP

Insofar as possible, inputs are derived from signals that are direct measurements of the desired variables for BOP systems.

4.9 Capability for Sensor Checks

The sensor checks are described in Subsection 7.3.1.1.8.1.

4.10 Capability for Test and Calibration

The ESFAS design complies with IEEE 338-1977, "Standard Criteria for the Periodic Testing of Nuclear Power Generating Station Protection System Actuation Functions," as discussed in Subsection 7.3.2.3.3.

4.11 Channel Bypass or Removal from Operation

NSSS

Any one of the four protection channels in the ESFAS may be tested, calibrated, or repaired without detrimental effect on the system. Individual

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actuation channels (e.g., pressurizer pressure, containment pressure, steam generator level) may be bypassed to create a two-out-of-three logic while maintaining the coincidence of two on the remaining channels. The single failure criterion is met during this condition.

BOP

Testing of the BOP ESFAS is done by channel actuation. Either one of the two channels may be calibrated or repaired without detrimental effects on the system. Individual actuation channels may be bypassed to effect a single channel logic on the ESFAS signal. Maintenance and calibration of the bypassed channel can be accomplished in a short time interval. Probability of failure of the remaining channel is acceptably low during such maintenance periods.

4.12 Operating Bypasses

NSSS

Operating bypass is provided as shown on Table 7.3-1. The operating bypass is automatically removed when the permissive condition is not met. The circuitry and devices which function to remove this inhibit are designed in accordance with IEEE 279-1971.

BOP

There are no operating bypasses for the BOP ESFAS.

4.13 Indication of Bypasses

Indication of test or bypass conditions, or removal of any channel from service is given by annunciators. The operating bypass that is

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automatically removed at a fixed setpoint is alarmed and indicated.

4.14 Access to Means for Bypassing

NSSS

Trip channel bypasses have access controlled by means of key-locked doors. When the first parameter is bypassed there is an audible and visible alarm to indicate which channel is being bypassed. The specific parameter or parameters which are being bypassed are indicated by lights at the PPS cabinet and its remote operator's module in the MCR.

The operating bypasses also have audible and visible alarms. The operating bypasses have automatic features which provide a permissive level at which they can be actuated and a second level at which they are automatically removed.

BOP

Local control panels containing the local control switches are located in the electrical equipment room under administrative control. The control switches in the main control room are under administrative control of the operators.

4.15 Multiple Setpoints

NSSS

Manual reduction of the setpoints for low pressurizer and low steam-generator pressures are used for the controlled reduction of pressures as discussed in Subsections 7.2.1.1.1.6 and 7.2.1.1.1.8. The setpoint reductions are initiated by main control board pushbuttons for each

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channel, one pushbutton for the pressurizer pressure and one pushbutton for both steam-generator pressures within the one channel. Operation of the pushbutton will reduce the pressure actuation setpoint a selected increment below the existing system pressure. As the pressurizer or steam generator pressure increases, the actuation setpoint will increase automatically with the pressure, maintaining a fixed increment, until the setpoint reaches its normal actuation setpoint value.

BOP

There are no multiple setpoints for the BOP ESFAS.

4.16 Completion of Protective Action Once It Is Initiated

NSSS

The ESFAS is designed to ensure that protective action will go to completion once initiated. Actuation of an ESFAS can be cleared by the operator manually resetting the ESFAS at the PPS cabinet and the ESFAS auxiliary relay cabinets. A protective action is initiated when the selective two-out-of-four logic reaches the proper coincidence-of-two state. A protective action is completed when all of the appropriate ESF-actuated components have assumed the proper state for their ESF function.

The cycling AFAS to the valves is not locked into the actuation but the latching AFAS to the pump is locked in. The cycling AFAS is designed to cycle based on the steam-generator level signal. When the low-level signal clears, the cycling AFAS is cleared until the level drops to the actuation setpoint again.

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Once protective action is initiated, it can be reversed by a subsequent deliberate action by the operator.

4.17 Manual Initiation

A manual initiation is effected by operating manual switches in the main control room. No single failure will prevent a manual actuation at the system level.

4.18 Access to Setpoint Adjustments, Calibration, and Test Points

Administrative control is provided for access to the instruments and devices for setpoint adjustment and calibration and test points.

4.19 Identification of Protective Action

Indication lights are provided for all protective actions, including identification of the channel trips.

4.20 Information Readout

Light, indicators, annunciators, and plant computer display the operating status of the system.

4.21 System Repair

Identification of a defective channel will be accomplished by observation of system status lights, or by testing as described in Subsection 7.3.1.1.8. Replacement or repair of components is accomplished with the affected channel bypassed. The affected function is then in a two-out-

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of-three logic, but still maintains a coincidence of two for actuation. For the one-out-of-two ESFAS, the affected trip function then operates in a single active channel trip logic.

4.22 Identification

All equipment associated with the actuation system, including panels, modules, and cables, is marked in order to facilitate identification. Interconnecting cabling is color coded as discussed in Subsection 8.3.1.3.

The compliance of the ESFAS to the requirements of IEEE 384-1981, "IEEE Standard Criteria for Independence of Class IE Equipment and Circuits," and Regulatory Guide 1.75, "Physical Independence of Electric Systems," is discussed in Subsection 7.1.2.10.

7.3.2.3.3 <u>Testing Criteria</u>

IEEE Standard 338-1977 and Regulatory Guide 1.22 provide guidance for development of procedures, equipment, and documentation for periodic testing. The basis for the scope and means of testing are described in this section. Test intervals and their bases are included in [I75] ~~Chapter 16, Technical Specifications.~~ The organization for testing and for documentation is described in Chapter 13. Since operation of the ESF system is not expected, the systems are periodically tested to verify operability. Complete channels can be individually tested without violating the single failure criterion and without inhibiting the operation of the systems. The majority of the system can be checked from the sensor signal through the actuation devices during reactor operation since ESF system operation does not damage equipment or disturb reactor operation. Thus, testing completely simulates valid actuation. Equipment that can not be tested during reactor operation are specified in [I75] ~~Chapter 16, Technical Specifications.~~ Minimum frequencies for checks, calibration, and periodic testing of the ESFAS instrumentation and control are

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also given in Chapter 16, Technical Specifications.

The use of individual trip and ground detection lights, in conjunction with those provided at the supply bus, ensure that possible grounds or shorts to another source of voltage will be detected.

The response time from an input signal to protect system trip bistables through the deenergization for NSSS ESFAS of the actuation relays is verified by measurement during plant startup testing. Sensor responses are measured during factory acceptance tests. Subsection 7.3.1.1.8.8 provides additional information on response time testing.

7.3.2.4 Failure Modes and Effects Analysis (FMEA)

The FMEA for the NSSS ESFAS appears on Table 7.2-5. The FMEA for the additional BOP ESF systems appears on Table 7.3-10, 7.3-11, 7.3-12 and 7.3-13.

7.3.2.5 Setpoint Methodology

NSSS

Refer to Subsection 7.2.2.5.

BOP

The setpoints for safety-related BOP instrumentation are established in accordance with Regulatory Guide 1.105 and ISA Standard S67.04.

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7.3.3 References

1. CENPD-148 "Review of Reactor Shutdown System (PPS Design) for Common Mode Failure Susceptibility," Combustion Engineering, Inc.

2. J774-AE-200-02 (A-357524-18) "FMEA Failure Mode Effects and Analysis," Forney International, Inc. 1

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TABLE 7.3-1

ESFAS BYPASSES

Title	Function	Initiated By	Removed By	Notes
Trip Channel Bypass	Disables any given trip channel	Manually by controlled access switch	Same switch	Interlocks allow one channel for any type trip to be bypassed at one time
Pressurizer Pressure Bypass	Disables low pressurizer pressure portion of SIAS/CIAS*	Manual switch (1 per channel)	Automatic if pressurizer pressure is > 500 psia (35 kg/cm² A)	

* SIAS/CIAS actuation due to high containment pressure not affected.

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TABLE 7.3-2

ONE-OUT-OF-TWO ESFAS BYPASSES

Title	Function	Initiated By	Removed By
Trip Channel Bypass*	Disables any given trip channel	Manually by controlled access switch	Same switch

* Only one channel is allowed for any type trip to be bypassed at one time. Limits on the bypassed channels are administratively controlled.

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TABLE 7.3-3

DESIGN-BASIS EVENTS REQUIRING ESF SYSTEM ACTION

Event	Containment Isolation	Containment Spray	Main Steam Isolation	Safety Injection	Auxiliary Feedwater	Control Room Emergency Ventilation	Fuel Building Emergency Ventilation	Containment Purge Isolation
Feedline Break	*	*	*		*			*
LOCA-Large Break	*	*		*		*		*
LOCA-Small Break#	*	*		*	*	*		*
Steam Generator Tube Rupture			##	*	*	*		
Steamline Break (Inside Containment)	*	*	*	*	*	*		*
Steamline Break (Outside Containment)###			*	*	*	*		
Fuel Handling Accident (Inside Containment)								*
Fuel Handling Accident (Inside Fuel Bldg.)							*	

Includes CEA ejection and pressurizer safety valve opening
Manual actuation
Includes opening of main steam safety valve.

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TABLE 7.3-4

MONITORED VARIABLES REQUIRED FOR ESFAS PROTECTIVE SIGNALS

	CIAS	CSAS	RAS	MSIS	SIAS	AFAS	CREVAS	FBEVAS	CPIAS
Pressurizer Pressure	3				3		3		
Containment Pressure	1	2		1	1		1		
Steam-Generator Pressure				3		4			
Refueling Water Tank Level			3						
Steam Generator Water Level				1		3			
Containment Upper Operating Area Radiation Level									1
Containment Refueling Machine Area Radiation Level									1
Spent Fuel Pool Area Radiation Level								1	
Control Room Air Intake Radiation Level							1		

Key: 1 - High

2 - High - High

3 - Low

4 - High - Differential

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TABLE 7.3-5

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM PLANT VARIABLE RANGES

Monitored Variable	Minimum	Nominal Full Power	Maximum
Pressurizer Pressure	0 psia	2250 psia ($158\ kg/cm^2A$)	3000 psia ($211\ kg/cm^2A$)
Containment Pressure (NR)	-4.3 psig ($-300\ cmH_2O$)	$0\ cmH_2O$	17.1 psig ($1200\ cmH_2O$)
Containment Pressure (WR)	-5.7 psig ($-400\ cmH_2O$)	0 psig ($0\ cmH_2O$)	79.7 psig ($5600\ cmH_2O$)
Steam Generator Pressure	0 psia	1070 psia ($75\ kg/cm^2A$)	1524 psia ($107.1\ kg/cm^2A$)
Refueling Water Tank Level	0%	-	100%
Steam-Generator Level (NR)	0%	44 %	100%
Steam-Generator Level (WR)	0%	79 %	100%
Containment Upper Operating Area Radiation Level	10^{-4} R/hr	-	10^{7} R/hr
Containment Refueling Machine Area Radiation Level	10^{-1} mR/hr	-	10^{4} mR/hr
Spent Fuel Pool Area Radiation Level	10^{-1} mR/hr	-	10^{5} mR/hr
Control Room Air Intake Radiation Level	$10^{-6}\ \mu Ci/cm^3$	-	$10^{-1}\ \mu Ci/cm^3$

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TABLE 7.3-6

NSSS ENGINEERED SAFETY FEATURES ACTUATION SYSTEM SENSORS

Monitored Variable	Sensor Type	Number of Sensors	Location
Pressurizer Pressure	Pressure transducer	4* (wide range)	Pressurizer
Containment Pressure (wide and narrow range)	Pressure transducer	8*	Outside containment
Steam Generator Pressure	Pressure transducer	4/Steam generator*	Steam generator
Refueling Water Tank Level	Differential pressure transducer	4	Refueling water tank
Steam Generator Level (wide and narrow Range)	Differential pressure transducer	8/Steam generator*	Steam generator

*Shared with the reactor protection system

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TABLE 7.3-7 (Sh. 1 of 2)

NSSS ENGINEERED SAFETY FEATURES ACTUATION SYSTEM SETPOINTS AND MARGINS TO ACTUATION

Actuation Signal	Nominal Full Power	Normal Operation Range	Nominal Actuation Setpoint	Nominal Margin to Actuation	
SIAS & CIAS					
Low Pressurizer Pressure	2250 psia (158 kg/㎠A)	2225-2275 psia (156-160 kg/㎠A)	1770.4 psia* (124.47 kg/㎠A)	454.6-504.6 psi (31.53-35.53 kg/㎠)	
High Containment Pressure	0 psig (0 cmH_2O)	± 0.5 psig (± 35 cmH_2O)	1.9 psig (133.75 cmH_2O)	1.4-2.4 psig (98.75-168.75 cmH_2O)	574
CSAS					
High-High Containment Pressure	0 psig (0 cmH_2O)	± 0.5 psig (± 35 cmH_2O)	20.1 psig (1421.0 cmH_2O)	19.6-20.6 psi (1386-1456 cmH_2O)	
RAS					
Low Refueling Water Tank Level	--	7.6-95%	7.6%	0-87.4%	
MSIS					
Low Steam Generator Pressure	1070 psia (75 kg/㎠A)	1070-1170 psia (75-82 kg/㎠A)	889.0 psia* (62.50 kg/㎠A)	181-281 psi (12.5-19.5 kg/㎠)	
High Containment Pressure	0 psig (0 cmH_2O)	± 0.5 psig (± 35 cmH_2O)	1.9 psig (133.75 cmH_2O)	1.4-2.4 psig (98.75-168.75 cmH_2O)	574
High Steam Generator Level (narrow range)	44%	30-74%	93.0%	19-63%	

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TABLE 7.3-7 (Sh. 2 of 2)

Actuation Signal	Nominal Full Power	Normal Operation Range	Nominal Actuation Setpoint	Nominal Margin to Actuation
AFAS				
Low Steam Generator Level (Wide range)	79%	72-90%	23.7%	48.3-66.3%
Steam Generator Differential Pressure**	0 psid	0 psid	239.4 psid (16.83 kg/cm²)	239.4 psi (16.83 kg/cm²)

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* Setpoint can be manually decreased as pressure is reduced and is automatically increased as pressure increases.

** This is a calculated, not sensed, variable.

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TABLE 7.3-8

BOP ESF SYSTEM ACTUATION SENSORS

Monitored Variable	Type	Number of Sensor	Location
Containment Upper Operating Area Radiation Level (RE-233/234)	Ion Chamber Geiger-Mueller	2	
Containment Refueling Machine Area Radiation Level	Geiger-Mueller	2	
Spent Fuel Pool Area Radiation Level	Geiger-Mueller	2	
Control Room Air Intake Radiation Level	ß-Scintillation	4	

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TABLE 7.3-9

BOP ESF SYSTEM ACTUATION SETPOINTS AND MARGIN TO ACTUATION

ACTUATION SIGNAL	NOMINAL	NORMAL OPERATION LIMIT	ACTUATION SETPOINT	MARGIN TO ACTUATION	
CPIAS					
Containment Upper Operating Area Radiation Level	100 mR/hr	350 mR/hr	2.8 R/hr	2.45 R/hr	100
Containment Refueling Machine Area Radiation Level	2 mR/hr	2.5 mR/hr* 50.0 mR/hr	12.5 mR/hr* 250.0 mR/hr	10.0 mR/hr 200.0 mR/hr	100
FBEVAS					
Spent Fuel Pool Area Radiation Level	2 mR/hr	2.5 mR/hr	20 mR/hr	17.5 mR/hr	
CREVAS					
Control Room Air Intake Radiation Level	Negligible	1.3×10^{-6} μCi/㎤	1.3×10^{-5} μCi/㎤	11.7×10^{-6} μCi/㎤	204

* When moving irradiated fuel in containment

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TABLE 7.3-10 (Sh. 1 of 5)

FUEL BUILDING EMERGENCY VENTILATION ACTUATION SIGNAL FAILURE

FAILURE MODES AND EFFECTS ANALYSIS

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Loss of One AC Power Division	Loss of redundancy	Immediate annunciation.	The other division of the system actuates.
Loss of One DC Power Division	Normal ventilation flow path isolation in one division.	Immediate annunciation on loss of bus. Disabled alarm on associated division.	Dampers fail in the safe position. Closure of fuel building normal supply and exhaust dampers. Actuation of emergency ventilation system and flow path is not affected.
Loss of Instrument Air System	Normal ventilation flow path isolation in one division.	Immediate annunciation on loss of instrument air.	Dampers fail in the safe position. Closure of fuel building normal supply and exhaust dampers. Actuation of emergency ventilation system and flow path is not affected.

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TABLE 7.3-10 (Sh. 2 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Radiation Sensor Fails			
HI	System actuates	Immediate annunciation. Periodic testing.	Actuation of both FBEVAS divisions.
LO	System becomes one-out-of-one.	Immediate annunciation. Periodic testing.	The other sensor channel and system level manual actuation available to actuate both divisions.
Analog Sensor Wiring Fails:			
Open	System becomes one-out-of-one.	Immediate annunciation. Periodic testing.	The other sensor channel and system level manual actuation available to actuate both divisions.
Short	System actuates	Immediate annunciation. Periodic testing.	Actuation of both FBEVAS divisions.

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TABLE 7.3-10 (Sh. 3 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bistable Fails			
Output contact fails in an open position.	System actuates	Immediate annunciation.	Actuation of both divisions.
Output contact fails in a closed position.	System becomes one-out-of-one.	Periodic testing.	The other channel and system level manual actuation available to actuate both divisions.
Manual Input Fails			
Fails to actuate	Loss of system level manual initiation for one division.	Periodic testing.	Automatic actuation and component level manual control fully operable and system level manual actuation available for the other division.
Fails in an actuate position.	System spurious actuation of one division.	Immediate annunciation.	Spurious actuation does not impair power generation over a short term.

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TABLE 7.3-10 (Sh. 4 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bypass Switch Fails			
Fails in a nonbypassed state.	Loss of bypass function.	Periodic testing.	No loss of automatic or manual actuation.
Fails in a bypassed state.	Blocks automatic actuation in one channel.	Immediate annunciation. Bypass lamp illuminated.	The other channel and system level manual actuation available to actuate both divisions.
ILS Output Relay Coil Fails			
Open or shorted	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
ILS Output Relay Mechanically Jammed			
In a closed position.	Actuation of associated equipment.	Visual indication of trouble condition on the control switch module for the associated equipment.	Controlled equipment is actuated in the same division.

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TABLE 7.3-10 (Sh. 5 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
ILS Output Relay Mechanically Jammed (Cont.)			
In an open position	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
Output Wiring Fails			
Open	Loss of redundancy	Visual disable indication and alarm in the main control room. Periodic testing.	Loss of equipment control from the main control room for that particular division equipment. The other division equipment available to actuate.
Short	Spurious actuation of the associated equipment.	Visual trouble indication and alarm in the main control room.	Spurious actuation

NOTE : Refer to FMEA of the ILS described in Subsection 7.3.3.

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TABLE 7.3-11 (Sh. 1 of 5)

CONTAINMENT PURGE ISOLATION ACTUATION SIGNAL

FAILURE MODES AND EFFECTS ANALYSIS

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Loss of One AC Power Division	System isolates	Immediate annunciation.	Trip and isolation
Loss of One DC Power Division	System isolates	Immediate annunciation on loss of bus. Disabled alarm on associated division.	Air operated containment purge isolation valves (CPIV) fail in the safe position. Closure of air operated CPIVs.
Loss of Instrument Air System	CPIVs fail closed	Immediate annunciation on loss of instrument air.	Air operated containment purge isolation valves (CPIV) fail in the safe position. Closure of air operated CPIV's

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TABLE 7.3-11 (Sh. 2 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Radiation Sensor Fails			
HI	System isolates	Immediate annunciation. Periodic testing.	Trip and isolation
LO	System becomes one-out-of-one.	Immediate annunciation.	The other sensor channel and system level manual actuation available to actuate both division.
Analog Sensor Wiring Fails			
Open	System becomes one-out-of-one.	Immediate annunciation. Periodic testing.	The other sensor channel and system level manual actuation available to actuate both divisions.
Short	System isolates	Immediate annunciation. Periodic testing.	Trip and isolation

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TABLE 7.3-11 (Sh. 3 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bistable Fails			
Output contact fails in an open position.	System isolates	Immediate annunciation.	Trip and isolation
Output contact fails in a close position.	System becomes one-out-of-one.	Periodic testing.	The other channel and system level manual actuation available to actuate both divisions.
Manual Input Fails			
Fails to actuate	Loss of system level manual initiation for one division.	Periodic testing	Automatic actuation and component level manual control fully operable and system level manual actuation available for the other division.
Fails in an actuate position.	System isolates	Immediate annunciation.	Trip and isolation

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TABLE 7.3-11 (Sh. 4 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bypass Switch Fails			
Fails in a nonbypassed state.	Loss of bypass function.	Periodic testing.	No loss of automatic or manual actuation.
Fails in a bypassed state.	Blocks automatic actuation in one channel.	Immediate annunciation. Bypass lamp illuminated.	Other channel and system level manual actuation available to actuate both divisions.
ILS Output Relay Coil Fails			
Open or shorted	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
ILS Output Relay Mechanically Jammed			
In a closed position	Actuation of associated equipment.	Visual indication of trouble condition on the control switch module for the associated equipment.	Controlled equipment is actuated in the same division.

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TABLE 7.3-11 (Sh. 5 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
ILS Output Relay Mechanically Jammed (Cont.)			
In an open position	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
Output Wiring Fails			
Open	Loss of redundancy	Visual disable indication & alarm in the main control room. Periodic testing.	Loss of equipment control from the main control room for that particular division equipment. The other division equipment available to actuate.
Short	Spurious actuation of the associated equipment. System isolates	Visual trouble indication and alarm in the main control room.	Spurious actuation and system isolation.

NOTE : Refer to FMEA of the ILS described in Subsection 7.3.3.

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TABLE 7.3-12 (Sh. 1 of 5)

CONTROL ROOM EMERGENCY VENTILATION ACTUATION SIGNAL

FAILURE MODES AND EFFECTS ANALYSIS

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Loss of One AC Power Division	Loss of redundancy	Immediate annunciation.	Other division of the system actuates.
Loss of One DC Power Division	Normal control room ventilation isolate in one division.	Immediate annunciation on loss of bus. Disabled alarm on associated division.	Dampers fail in the safe position. Closure of fuel building normal supply and exhaust dampers. Actuation of emergency ventilation system 7 flow path is not affected.
Loss of instrument air system	Normal control room ventilation isolate in one division.	Immediate annunciation on loss of instrument air.	Dampers fail in the safe position. Closure of fuel building normal supply and exhaust dampers. Actuation of emergency ventilation system and flow path is not affected.

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TABLE 7.3-12 (Sh. 2 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Radiation Sensor Fails			
HI	System actuates.	Immediate annunciation. Periodic testing.	Actuation of both CREVAS divisions.
LO	System becomes one-out-of-one.	Immediate annunciation.	The other sensor channel and system level manual actuation available to actuate both division.
Analog Sensor Wiring Fails			
Open	System becomes one-out-of-one.	Immediate annunciation. Periodic testing.	The other sensor channel and system level manual actuation available to actuate both division.
Short	System actuates	Immediate annunciation. Periodic testing.	Actuation of both CREVAS divisions.

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TABLE 7.3-12 (Sh. 3 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bistable Fails			
Output contact fails in an open position.	System actuates.	Immediate annunciation.	Actuation of both divisions.
Output contact fails in a close position.	System becomes one-out-of-one.	Periodic testing.	The other channel and system level manual actuation available to actuate both divisions.
Manual Input Fails			
Fails to actuate	Loss of system level manual initiation for one division.	Periodic testing.	Automatic actuation and component level manual control fully operable and system level manual actuation available for the other division.
Fails in an actuate position.	System spurious actuation of one division.	Immediate annunciation.	Spurious actuation does not impair power generation over a short term.

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TABLE 7.3-12 (Sh. 4 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Bypass Switch Fails :			
Fails in a nonbypassed state.	Loss of bypass function.	Periodic testing.	No loss of automatic or manual actuation.
Fails in a bypassed state.	Blocks automatic actuation in one channel.	Immediate annunciation. Bypass lamp illuminated.	The other channel and system level manual actuation available to actuate both divisions.
ILS Output Relay Coil Fails			
Open or shorted	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
ILS Output Relay Mechanically Jammed			
In a closed position	Actuation of associated equipment.	Visual indication of trouble condition on the control switch module for the associated equipment.	Controlled equipment is actuated in the same division.

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TABLE 7.3-12 (Sh. 5 of 5)

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
ILS Output Relay Mechanically Jammed (Cont.)			
In an open position	No automatic actuation of associated equipment in one division.	Periodic testing.	Component level manual control and redundant equipment control in the other division available to actuate.
Output Wiring Fails			
Open	Loss of redundancy	Visual disable indication and alarm in the control room. Periodic testing.	Loss of equipment control from the main control room for that particular division equipment. The other division equipment available to actuate.
Short	Spurious actuation of the associated equipment.	Visual trouble indication and alarm in the main control room.	Spurious actuation.
SIS input open	Loss of one sensing parameter in one division	Periodic testing.	Automatic and manual actuation of both divisions are fully operable.
SIS input shorted	Spurious actuation of the associated division	Visual indication in the main control room.	Spurious action.

NOTE : Refer to FMEA of the ILS described in Subsection 7.3.3.

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TABLE 7.3-13

CONTAINMENT COMBUSTIBLE GAS CONTROL SYSTEM

FAILURE MODES AND EFFECTS ANALYSIS

FAILURE MODE	EFFECT ON SYSTEM	DETECTION	REMARK
Loss of One AC Power Division	Loss of redundancy	Immediate annunciation.	Other division of the system are fully operable.
Control Switch or Wiring Failure			
Open	Loss of redundancy	Periodic testing.	Loss of equipment control from the main control room. The other division equipment available to actuate.
Short	Spurious operation may occur	Periodic testing. Visual indication in the main control room.	Loss of equipment control from the main control room. The other division equipment available to actuate.

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TABLE 7.3-14

SENSOR RESPONSE TIME AND ACCURACIES OF ESFAS MEASUREMENT CHANNELS

SENSOR DESCRIPTION	SENSOR RESPONSE TIME	ESFAS RESPONSE TIME	ACCURACIES OF ESFAS MEASUREMENT CHANNELS (LOGARITHMIC SCALE READING)
Containment Upper operating Area Radiation	< 0.6 sec	< 0.1 sec	± 20 %
Containment Refueling Machine Area Radiation	< 0.6 sec	< 0.1 sec	± 22 %
Spent Fuel Pool Area Radiation	< 0.6 sec	< 0.1 sec	± 22 %
Control Room Air Intake Radiation	< 0.6 sec	< 0.1 sec	± 32 %

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ACTUATED DEVICES LIST INITIATED BY THE NSSS ESFAS

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2. CONTAINMENT SPRAY ACTUATION SIGNAL (CSAS)

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3. RECIRCULATION ACTUATION SIGNAL (RAS)

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4. CONTAINMENT ISOLATION ACTUATION SIGNAL (CIAS)

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TABLE 7.3-15 (Sh. 7 of 9)

4. CONTAINMENT ISOLATION ACTUATION SIGNAL (CIAS) (CONT.)

TABLE 7.3-15 (Sh. 8 of 9)

5. MAIN STEAM ISOLATION SIGNAL (MSIS)

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TABLE 7.3-15 (Sh. 9 of 9)

6. AUX. FEEDWATER ACTUATION SIGNAL

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TABLE 7.3-16 (Sh. 1 of 2)

ACTUATED DEVICES LIST INITIATED BY THE BOP ESFAS

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TABLE 7.3-16 (Sh. 2 of 2)

4. DIESEL-GENERATOR LOADING SEQUENCER ACTUATION SIGNAL

* NOTE: LPSI pump will be stopped by the RAS signal.

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TABLE 7.3-17(Sh. 1 of 4)

ENGINEERED SAFETY FEATURES RESPONSE TIMES

INITIATING SIGNAL AND FUNCTION	RESPONSE TIME IN SECONDS
1. Manual	
a. SIAS	
Safety Injection (ECCS)	Not Applicable
Containment Isolation	Not Applicable
Containment Purge Valve Isolation	Not Applicable
b. CSAS	
Containment Spray	Not Applicable
c. CIAS	
Containment Isolation	Not Applicable
d. MSIS	
Main Steam Isolation	Not Applicable
e. RAS	
Containment Sump Recirculation	Not Applicable
f. AFAS	
Auxiliary Feedwater Pumps	Not Applicable
g. CREVAS	Not Applicable
h. FBEVAS	Not Applicable
I. CPIAS	Not Applicable
2. Pressurizer Pressure - Low	
a. Safety Injection (HPSI)	$\leq$ 30
b. Safety Injection (LPSI)	$\leq$ 50

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TABLE 7.3-17(Sh. 2 of 4)

ENGINEERED SAFETY FEATURES RESPONSE TIMES

INITIATING SIGNAL AND FUNCTION	RESPONSE TIME IN SECONDS
c. Containment Isolation	
1. CIAS actuated mini-purge valves	≤ 5
2. other CIAS actuated valves	≤ 70*/60**
3. Containment Pressure - High	
a. Safety Injection (HPSI)	≤ 30
b. Safety Injection (LPSI)	≤ 50
c. Containment Isolation	
1. CIAS actuated mini-purge valves	≤ 5
2. Other CIAS actuated valves	≤ 70*/60**
d. Main Steam Isolation	
1. MSIS actuated MSIVs	≤ 5
2. MSIS actuated MFIVs	≤ 10
4. Containment Pressure - High-High	
a. Containment Spray Pump	≤ 33.5*/23.5**
b. Containment Isolation Valves Closed on CSAS	≤ 50*/40**
5. Steam Generator Pressure - Low	
a. Main Steam Isolation	
1. MSIS actuated MSIVs	≤ 5
2. MSIS actuated MFIVs	≤ 10

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TABLE 7.3-17(Sh. 3 of 4)

ENGINEERED SAFETY FEATURES RESPONSE TIMES

INITIATING SIGNAL AND FUNCTION	RESPONSE TIME IN SECONDS
6. Refueling Water Tank - Low	
a. Containment Recirculation Sump Recirculation	< 60
7. Steam Generator Level - Low	
a. Auxiliary Feedwater (Motor Driven)	≤ 45
b. Auxiliary Feedwater (Diesel Driven)	≤ 45
8. Steam Generator Level - High	
a. Main Steam Isolation	
1. MSIS actuated MSIVs	≤ 5
2. MSIS actuated MFIVs	≤ 10
9. Steam Generator P-High-Coincident With Steam Generator Level Low	
a. Auxiliary Feedwater Isolation from the Reuptured Steam Generator	≤ 15
10. CREVAS	
Control Room Air Intake Radiation - High	
a. CREVAS Actuated Isolation Dampers	< 8.2 sec
b. Emergency Makeup ACU Fan	< 4.2 sec ***
11. FBEVAS	
Fuel Building Spent Fuel Pool Area Radiation - High	
a. FBEVAS Actuated Isolation Dampers	< 8.2 sec
b. Emergency ACU Fan	< 4.2 sec ***
c. Normal ACU Fan	< 4.2 sec ***

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ENGINEERED SAFETY FEATURES RESPONSE TIMES

INITIATING SIGNAL AND FUNCTION	RESPONSE TIME IN SECONDS
12. CPIAS	
Containment Upper Operating Area/ Refueling Machine Bridge Area Radiation - High	
a. CPIAS Actuated Isolation Dampers	< 8.2 sec
b. High-Volume Purge Fan	NA
13. (4.16kV) Emergency Bus Undervoltage (Degraded Voltage)	
Loss of Power 90% System voltage	< 5 min 322
14. (4.16kV) Emergency Bus Undervoltage (Loss of Voltage)	
Loss of Power	< 1 sec

TABLE NOTATIONS

* Emergency diesel generator starting and sequence loading delays included. Response time limit includes movement of valves and attainment of pump or blower discharge pressure.

** Emergency diesel generator starting delays not included. Offsite power available. Response time limit includes movement of valves and attainment of pump or blower discharge pressure.

*** Fan motor run-up time is not included since building volume is too large to make a substantial change to pressure compared to the isolation function.

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NSSS ESFAS SIGNAL LOGIC (SIAS)
(Sheet 1 of 4)

Figure 7.3-1

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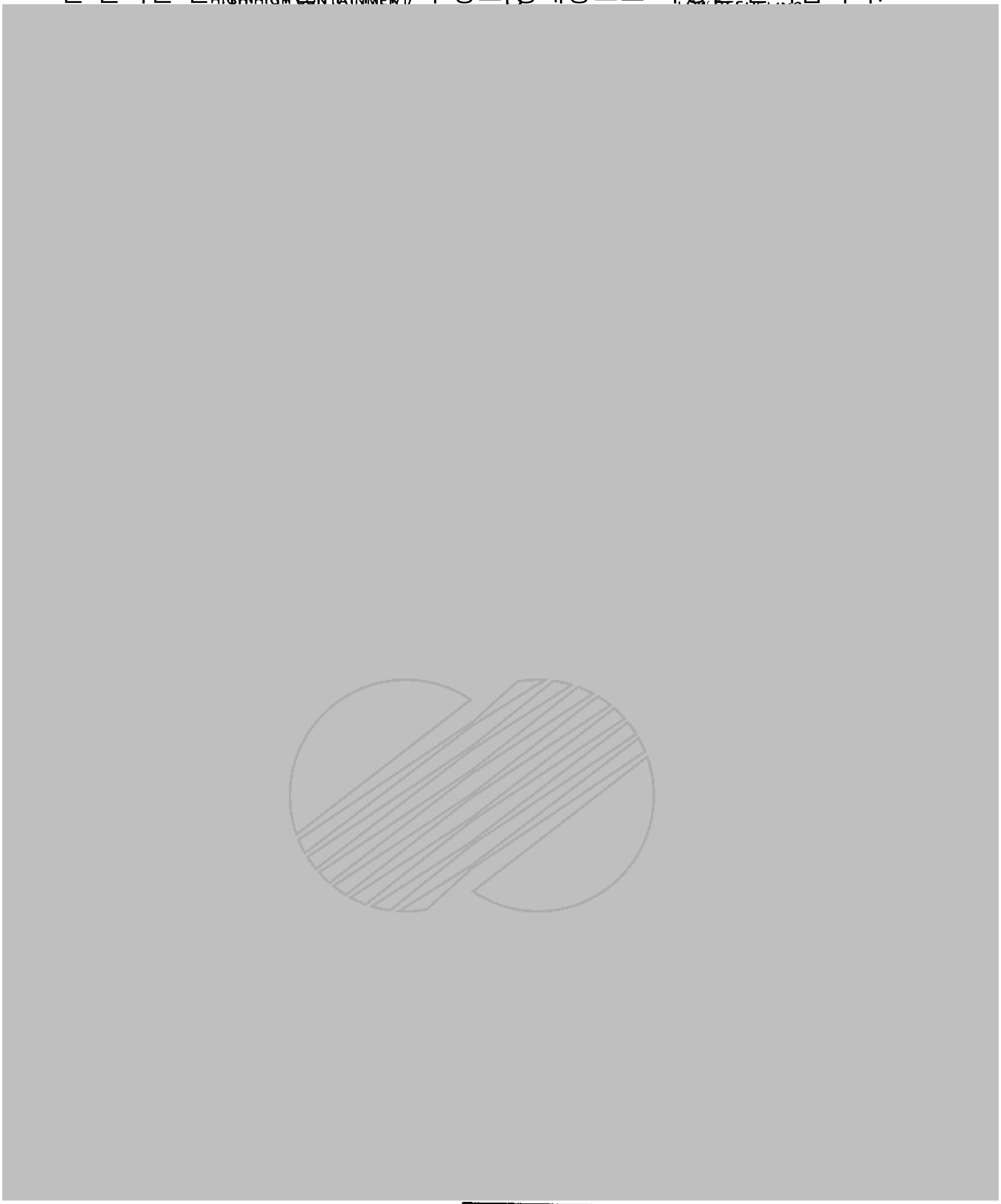

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NSSS ESFAS SIGNAL LOGIC
(CSAS, CIAS, RAS)
(Sheet 2 of 4)

Figure 7.3-1

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NSSS ESFAS SIGNAL LOGIC (MSIS)
(Sheet 3 of 4)

Figure 7.3-1

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NSSS ESFAS SIGNAL LOGIC
(AFAS 1, AFAS 2)
(Sheet 4 of 4)

Figure 7.3-1

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FUNCTIONAL DIAGRAM OF A
TYPICAL NSSS ENGINEERED SAFETY
FEATURE ACTUATION

Figure 7.3-2

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BOP ESFAS LOGIC LEGEND

Figure 7.3-3

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BOP ESFAS SIGNAL LOGIC (CREVAS)
(Sheet 1 of 2)

Figure 7.3-4

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BOP ESFAS SIGNAL LOGIC (CREVAS)
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Figure 7.3-4

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BOP ESFAS SIGNAL LOGIC (FBEVAS)
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Figure 7.3-5

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BOP ESFAS SIGNAL LOGIC (FBEVAS)
(Sheet 2 of 2)

Figure 7.3-5

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SEE INSTRUMENT & EQUIPMENT INDEX
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BOP ESFAS SIGNAL LOGIC (CPIAS)
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Figure 7.3-6

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Figure 7.3-6

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TYPICAL ILS CONTROL LOGIC DIAGRAM MEDIUM VOLTAGE SWITCHGEAR AND LOAD CENTER CIRCUITS

(Sheet 1 of 5)

Figure 7.3-7

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TYPICAL ILS CONTROL LOGIC DIAGRAM
MEDIUM VOLTAGE SWITCHGEAR AND LOAD
CENTER CIRCUITS
(Sheet 2 of 5)

Figure 7.3-7

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TYPICAL ILS CONTROL LOGIC DIAGRAM
MEDIUM VOLTAGE SWITCHGEAR AND LOAD
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Figure 7.3-7

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TYPICAL ILS CONTROL LOGIC DIAGRAM
MEDIUM VOLTAGE SWITCHGEAR AND LOAD
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(Sheet 4 of 5)

Figure 7.3-7

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TYPICAL ILS CONTROL LOGIC DIAGRAM
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NSSS CONTROL CIRCUIT FOR A SOLENOID-ACTUATED, AIR-OPERATED VALVE

Figure 7.3-8

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NSSS CONTROL CIRCUIT FOR A MOTOR-OPERATED VALVE

Figure 7.3-9

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NSSS CONTROL CIRCUIT FOR A PUMP MOTOR

Figure 7.3-10

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LOAD SEQUENCER LOGIC
(Sheet 1 of 3)

Figure 7.3-11

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NSSS ESFAS AUXILIARY RELAY CABINET
SCHEMATIC DIAGRAM
(AFAS OR MSIS)
(Sheet 1 of 2)

Figure 7.3-12

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NSSS ESFAS AUXILIARY RELAY CABINET
SCHEMATIC DIAGRAM
(TYPICAL ACTUATION SIGNAL)
(Sheet 2 of 2)

Figure 7.3-12

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